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FORM PTO-1390) (REV. 9-2001) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEY'S DOCKET NUMBER **501.41304X00 filed March 7, 2002** U S APPLICATION NO. (If known, see 37 CFR 1 5) 10/070538
INTERNATIONAL APPLICATION NO **PCT/JP00/06009**	INTERNATIONAL FILING DATE **September 5, 2000**	PRIORITY DATE CLAIMED **September 7, 1999**
TITLE OF INVENTION **LIQUID CRYSTAL DISPLAY DEVICE**		
APPLICANT(S) FOR DO/EO/US **ONO, KIKUO YONEYA, MAKOTO YAMAMOTO, TSUNENORI HIRAKATA, JUNICHI NAKAYOSHI, YOSHIAKI**		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)))
   - a. ☐ is transmitted hereto (required only if not communicated by the International Bureau).
   - b. ☒ has been communicated by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office(RO/US)
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☒ is attached hereto.
   - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   - b. ☐ have been communicated by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording A separate cover sheet in compliance with 37 CFR 3 28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☒ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: **Figs. 1-5,6A-6B,7A-7B,8A-8B,9A-9b,10-41,42A-42B,43-50; Credit Card Payment Form**

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U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 10/070538	INTERNATIONAL APPLICATION NO PCT/JP00/06009	ATTORNEY'S DOCKET NUMBER 501.41304X00

21. The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492(a) (1) - (5)):

☐ Neither international preliminary examination fee (37 CFR 1 482) nor international search fee (37 CFR 1 445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO. **$1040.00**

☒ International preliminary examination fee (37 CFR 1 482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**

☐ International preliminary examination fee (37 CFR 1 482) not paid to USPTO but international search fee (37 CFR 1 445(a)(2)) paid to USPTO **$740.00**

☐ International preliminary examination fee (37 CFR 1 482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**

☐ International preliminary examination fee (37 CFR 1 482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4).......... **$100.00**

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				**$**	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	**$**	
Total Claims	**56 - 20 =**	**36**	x **$18.00**	**$648.00**	
Independent Claims	**22 - 3 =**	**19**	x **$84.00**	**$1,596.00**	
MULTIPLE DEPENDENT CLAIMS(S) (if applicable) **280.00**			+ **$280.00**	**$280.00**	
TOTAL OF ABOVE CALCULATIONS =				**$3,414.00**	
☐ Applicant claims small entity status See 37 CFR 1.27 The fees indicated above are reduced by ½. +				**$**	
SUBTOTAL =				**$3,414.00**	
Processing fee of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1 492(f))				**$**	
TOTAL NATIONAL FEE =				**$3,414.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3 28, 3.31). **$40.00** per property +				**$40.00**	
TOTAL FEES ENCLOSED =				**$3,454.00**	
				Amount to be refunded:	$
				charged:	$

a. ☐ A check in the amount of $______ to cover the fees is enclosed

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c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposition Account No. **01-2135**. A duplicate copy of this sheet is enclosed

d. ☒ Fees are to be charged to a credit card **WARNING:** Information on this form may become public **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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22,466
REGISTRATION NO.

50/PRTS 10/070538

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Description

LIQUID CRYSTAL DISPLAY DEVICE DEVICE

Technical Field

The present invention relates to a liquid crystal display device, and more particularly to a so-called "lateral electric field type" liquid crystal display device.

Background of the Invention

A liquid crystal display device which is referred to as a "lateral electric field type" is constituted such that a pair of transparent substrates are arranged to face each other in an opposed manner by way of liquid crystal, and pixel electrodes and counter electrodes which generate an electric field (lateral electric field) parallel to the transparent substrate between the counter electrode and the pixel electrode are formed on each pixel region at a liquid-crystal side of one of such transparent substrates.

With respect to light which passes through the region between the pixel electrode and the counter electrode, a quantity of light is controlled by the driving of liquid crystal to which the above-mentioned electric field is applied.

Such a liquid crystal display device is known as a display device having broad viewing angle characteristics whose display

is not changed even when viewed from a direction oblique to a display surface.

Then, heretofore, the above-mentioned pixel electrode and the above-mentioned counter electrode have been formed of a conductive layer which prevents the transmission of light therethrough.

However, recently, there has been known a liquid crystal display device having a constitution in which counter electrodes formed of a transparent electrode are formed on the whole pixel regions except for peripheries of the pixel regions, and strip-like pixel electrodes which are extended in one direction and are arranged in parallel in the direction intersecting such one direction are formed on the counter electrodes by way of an insulation film.

In the liquid crystal display device having such a constitution, the lateral electric field is generated between the pixel electrode and the counter electrode so that the liquid crystal display device can largely enhance the numerical aperture while still maintaining the excellent broad viewing angle characteristics.

Such a technique is described in, for example, in SID (Society for Information Display) 99 DIGEST : p202 to p205 or Japanese Laid-open Patent Publication 202356/1999.

Disclosure of the Invention

Although the liquid crystal display device can drastically improve the viewing angle characteristics and the numerical aperture by adopting the above-mentioned liquid crystal driving method of the lateral electric field type, this also brings about various kinds of new technical problems to be solved.

For example, with respect to the liquid crystal display device having the above-mentioned constitution, although there has been an attempt to use a so-called multi-domain method which provides regions where the twisting directions of liquid crystal molecules become reverse to each other in each pixel of the liquid crystal display device and offsets the difference of coloring which is generated when the display region is viewed from the left and right directions, it has been found that the liquid crystal display device needs to perform various improvements from a viewpoint of the display quality.

The present invention has been made in view of such a circumstance and it is an object of the present invention to enhance the performance of display operation (driving performance of liquid crystal molecules) of the liquid crystal display device of the above-mentioned so-called lateral electric field type and to improve the display quality of such a liquid crystal display device.

To briefly explain the summary of typical examples of the novel liquid crystal display device disclosed in the present

application, they are as follows.

An example of the novel liquid crystal display device is characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on a pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, an electric field having a component parallel to the transparent substrates is generated between these electrodes, one electrode out of the pixel electrode and the counter electrode is constituted of a transparent electrode which is formed on a region disposed around the other electrode and not superposed on the other electrode, and an insulation film has a multi-layered structure (structure in which the insulation films are laminated at least in two layers).

In the liquid crystal display device having such a constitution, although the pixel electrode and the counter electrode which are arranged by way of the insulation film form a capacitive element at a portion where these electrodes are superposed each other, when the superposed area becomes large, the capacitive element takes a value which exceeds a necessary value.

Accordingly, by making the insulation film disposed between the pixel electrode and the counter electrode have a multi-layered structure, it is possible to decrease the

capacitance value of the capacitive element to a desired value.

Another example of the novel liquid crystal display device is characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on a rectangular pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, an electric field having a component parallel to the transparent substrates is generated between these electrodes, the counter electrode is constituted of a transparent electrode which is formed on a region disposed around the pixel electrode and not superposed on the pixel electrode, and the pixel electrode comprises a plurality of electrodes which are arranged in parallel in the direction perpendicular to an extension direction of the pixel electrode, wherein a plurality of electrodes consist of first electrodes having bent portions which change the extension direction and a second electrode which is extended linearly at least at a portion of a periphery of the pixel region.

In the liquid crystal display device having such a constitution, with respect to the pixel electrode, besides the first electrodes, the second electrode which is extended linearly is newly mounted on at least a portion of the periphery of the pixel region, that is, a portion (a dead space) where a lateral electric field is hardly generated since the first

electrodes have the bent portions, whereby the lateral electric field is also generated between the second electrode and the counter electrode.

Accordingly, the generation of the dead space can be suppressed so that the pixel region can be substantially increased.

These and other objects, features and advantageous effects according to the present invention will be more explicitly described by relating the description of the mode for carrying out the invention to the attached drawings.

Brief Description of the Drawings

Fig. 1 is a plan view for showing one embodiment of a pixel region of a liquid crystal display device according to the present invention.

Fig. 2 is a cross-sectional view taken along a line 2-2 of Fig. 1.

Fig. 3 is a cross-sectional view taken along a line 3-3 of Fig. 1.

Fig. 4 is a cross-sectional view taken along a line 4-4 of Fig. 1.

Fig. 5 is a plan view showing an external appearance of a liquid crystal display panel which is incorporated into the liquid crystal display device according to the present invention.

Fig. 6 is a cross-sectional view showing the constitution of a seal member which is served for fixing respective transparent substrates of the liquid crystal display panel and for sealing liquid crystal in a space defined by respective transparent substrates.

Fig. 7 is a constitutional view showing one embodiment of a gate signal terminal of the liquid crystal display device according to the present invention.

Fig. 8 is a constitutional view showing one embodiment of a drain signal terminal of the liquid crystal display device according to the present invention.

Fig. 9 is a constitutional view showing one embodiment of a counter voltage signal terminal of the liquid crystal display device according to the present invention.

Fig. 10 is an equivalent circuit diagram showing one embodiment of the liquid crystal display device according to the present invention.

Fig. 11 is a timing chart showing one embodiment of the driving of the liquid crystal display device according to the present invention.

Fig. 12 is a plan view of the liquid crystal display device according to the present invention in a state that external circuits are connected to the liquid crystal display panel.

Fig. 13 is a flow chart showing one embodiment of a

fabricating method of the liquid crystal display device according to the present invention.

Fig. 14 is a flow chart showing one embodiment of a fabricating method of the liquid crystal display device according to the present invention, wherein the flow chart explains steps which follow the steps explained in conjunction with the above-mentioned Fig. 13.

Fig. 15 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 16 is a cross-sectional view taken along a line 16-16 of Fig. 15.

Fig. 17 is a cross-sectional view taken along a line 17-17 of Fig. 15.

Fig. 18 is a cross-sectional view taken along a line 18-18 of Fig. 15.

Fig. 19 is a flow chart showing another embodiment of the fabricating method of the liquid crystal display device according to the present invention.

Fig. 20 is a flow chart showing another embodiment of the fabricating method of the liquid crystal display device according to the present invention, wherein the flow chart explains steps which follows the steps explained in conjunction with the above-mentioned Fig. 19.

Fig. 21 is a plan view showing another embodiment of the

pixel region of the liquid crystal display device according to the present invention.

Fig. 22 is a cross-sectional view taken along a line 22-22 of Fig. 21.

Fig. 23 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 24 is a cross-sectional view taken along a line 24-24 of Fig. 23.

Fig. 25 is a cross-sectional view taken along a line 25-25 of Fig. 23.

Fig. 26 is a cross-sectional view taken along a line 26-26 of Fig. 23.

Fig. 27 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 28 is a cross-sectional view taken along a line 28-28 of Fig. 27.

Fig. 29 is a cross-sectional view taken along a line 29-29 of Fig. 27.

Fig. 30 is a cross-sectional view taken along a line 30-30 of Fig. 27.

Fig. 31 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 32 is a cross-sectional view taken along a line 32-32 of Fig. 31.

Fig. 33 is a cross-sectional view taken along a line 33-33 of Fig. 31.

Fig. 34 is a cross-sectional view taken along a line 34-34 of Fig. 31.

Fig. 35 is a graph showing the characteristics of applied voltage-transmissivity of the liquid crystal display devices of the above-mentioned respective embodiments.

Fig. 36 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 37 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 38 is a cross-sectional view taken along a line 38-38 of Fig. 37.

Fig. 39 is a cross-sectional view taken along a line 39-39 of Fig. 37.

Fig. 40 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 41 is a cross-sectional view taken along a line 41-41 of Fig. 40.

Fig. 42 is an explanatory view showing another embodiment

of the pixel region of the liquid crystal display device according to the present invention.

Fig. 43 is a cross-sectional view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 44 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 45 is a cross-sectional view taken along a line 45-45 of Fig. 44.

Fig. 46 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 47 is a cross-sectional view taken along a line 47-47 of Fig. 46.

Fig. 48 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 49 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Fig. 50 is a plan view showing another embodiment of the pixel region of the liquid crystal display device according to the present invention.

Best Mode for Carrying out the Invention

A liquid crystal display device according to the present invention is explained in more detail in conjunction with embodiments hereinafter.

[Embodiment 1]

«Constitution of pixel»

Fig. 1 is a constitutional view of a pixel region of a liquid crystal display device (panel) according to the present invention and is a plan view as viewed from a liquid-crystal side of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner while sandwiching liquid crystal therebetween.

A cross-sectional view taken along a line 2-2 of Fig. 1 is shown in Fig. 2, a cross-sectional view taken along a line 3-3 of Fig. 1 is shown in Fig. 3, and a cross-sectional view taken along a line 4-4 in Fig. 1 is shown in Fig. 4.

First of all, in Fig. 1, gate signal lines GL which are extended in the x direction in the drawing and are arranged in parallel in the y direction in the drawing are formed of chromium (Cr), for example. Rectangular regions are formed by these gate signal lines GL and drain signal lines DL which will be explained later and these regions constitute pixel regions.

Then, in the pixel region, counter electrodes CT which generate an electric field between the counter electrodes CT and pixel electrodes PX which will be explained later are formed

on the whole area of the pixel region except for periphery thereof. The counter electrodes CT are formed of a transparent conductive bodies such as ITO1 (Indium-Tin-Oxide), for example.

With respect to the counter electrodes CT, a counter voltage signal line CL which is connected to the counter electrode CT is formed such that the counter voltage signal line CL frames the whole area of a periphery of the counter electrode CT, and the counter voltage signal lines CL is integrally formed with counter voltage signal lines CL which are formed in the same manner as the counter electrode CT on the left and right pixel regions in the drawing (respective pixel regions arranged along the gate signal lines GL).

In this case, the connection of both counter voltage signal lines CL in the pixel regions is performed at an upper portions and lower portions of the pixel regions respectively. Such a connection is made to minimize portions where the counter voltage signal line CL and the drain signal line DL which will be explained later are superposed so as to reduce the capacitance generated between them.

The counter voltage signal lines CL are made of opaque material such as chromium (Cr). In such a case, an electric field which functions as a noise is generated between the drain signal line DL which will be explained later and a peripheral portion of the counter electrode CT which is disposed close to the drain signal line DL so that the light transmissivity of

the liquid crystal may not be obtained as desired. However, since such a portion is shielded from light due to the counter voltage signal line CL, a drawback in terms of display quality can be resolved.

This implies that the drawback derived from the electric field (noise) which is generated between the gate signal line GL and a peripheral portion of the counter electrode CT which is disposed close to the gate signal line GL can be also resolved.

Further, as mentioned above, by making material of the counter voltage signal line CL equal to material of the gate signal line GL, these signal lines can be formed in the same step so that the increase of man-hours for fabricating can be obviated.

Here, it is needless to say that the above-mentioned counter voltage signal lines CL are not limited to Cr and may be formed of, for example, Al or material containing Al.

However, in this case, it is more advantageous to position the counter voltage signal line CL as an upper layer with respect to the counter electrode CT. This is because that a selective etchant (for example, HBr) for an ITO film which constitutes the counter electrode CT easily resolves Al.

Further, it is advantageous to interpose metal of a high melting point such as Ti, Cr, Mo, Ta, W at least on a contact surface between the counter voltage signal line CL and the counter electrode CT. This is because that ITO which

constitutes the counter electrode CT oxidizes Al in the counter voltage signal line CL thus forming a high resistance layer.

Accordingly, in one embodiment, when the counter voltage signal lines CL are formed of Al or material containing Al, it is preferable to adopt a multi-layered structure which uses the above-mentioned metal of a high melting point as a first layer.

Then, on an upper surface of the transparent substrate on which the counter electrodes CT, the counter voltage signal lines CL and the gate signal lines GL are formed, an insulation film GI which is made of SiN, for example, is formed such that the insulation film GI covers them.

The insulation film GI functions as an interlayer insulation film of the counter voltage signal lines CL and the gate signal lines GL with respect to the drain signals DL which will be explained later, functions as a gate insulation film in regions where thin film transistors TFT which will be explained later are formed, and functions as a dielectric film in regions where capacitive elements Cstg which will be explained later are formed.

Then, the thin film transistor TFT is formed in a superposed manner on a portion (left lower portion in the drawing) of the gate signal line GL and a semiconductor layer AS which is made of a-Si, for example, is formed on the insulation film GI at the portion.

By forming a source electrode SD1 and a drain electrode

SD2 on an upper surface of the semiconductor layer AS, a MIS type transistor having an inverse stagger structure which uses a portion of the gate signal line GL as a gate electrode is formed. Here, the source electrode SD1 and the drain electrode SD2 are simultaneously formed with the drain signal line DL.

That is, the drain signal lines DL which are extended in the y direction and are arranged in parallel in the x direction in Fig. 1 are formed and portions of these drain signal lines DL are extended over the surface of the semiconductor layer AS so as to form the drain electrodes SD2 of the thin film transistors TFT.

Further, the source electrodes SD1 are formed at the time of forming the drain signal lines DL and these source electrodes SD1 are also extended to the inside of the pixel region so as to integrally form contact portions which are served for connecting the source electrodes SD1 with pixel electrodes PX which will be explained later.

Here, as shown in Fig. 3, a contact layer d0 doped with n-type impurity, for example, is formed on interfaces between the semiconductor layer AS and the above-mentioned source electrode SD1 and the drain electrode SD2.

The contact layer d0 is formed such that an n-type impurity doping layer is formed on the whole area of the surface of the semiconductor layer AS, the source electrode SD1 and the drain electrode SD2 are formed, and thereafter, using these

respective electrodes as masks, the n-type impurity doping layer formed on the surface of the semiconductor layer AS which is exposed from respective electrodes is etched.

In this embodiment, the semiconductor layer AS is formed not only on the region where the thin film transistor TFT is formed but also on portions where the gate signal lines GL and the counter voltage signal lines CL intersect the drain signal lines DL. Such a provision is made to strengthen the function of the semiconductor layer AS as the interlayer insulation film.

On the surface of the transparent substrate on which the thin film transistors TFT are formed in this manner, a protective film PSV which is made of SiN, for example, is formed such that the protective film PSV also covers the thin film transistors TFT. The protective film PSV is provided for avoiding the direct contact of the thin film transistors TFT with the liquid crystal LC.

Further, on an upper surface of the protective film PSV, pixel electrodes PX are formed using transparent conductive films made of ITO2 (Indium-Tin-Oxide), for example.

The pixel electrodes PX are superposed on the regions where the above-mentioned counter electrode CT is formed. In this embodiment, five pieces of pixel electrodes PX are formed and these pixel electrodes PX are respectively extended in the y direction while being equally spaced apart from each other, wherein these pixel electrodes PX are connected with each other

at both ends thereof by means of layers made of same material which are respectively extended in the x direction.

In this embodiment, a distance L between the neighboring pixel electrodes PX is set to a value in a range of 1 to 15 μm, for example, and a width W of the pixel electrode PX is set to a value in a range of 1 to 10 μm, for example.

Here, the material layers at lower ends of respective pixel electrodes PX are connected to contact portions of the source electrodes SD1 of the above-mentioned thin film transistors TFT through contact holes formed in the protective film PSV, while the material layers at upper ends of respective pixel electrodes PX are formed in a superposed manner on the above-mentioned counter voltage signal lines CL.

Due to such a constitution, at portions where the counter electrode CT and respective pixel electrodes PX are superposed, capacitive elements Cstg which use the lamination film formed of the insulation film GI and the protective film PSV as the dielectric film are formed.

The capacitive elements Cstg are provided for storing video signals in the pixel electrodes PX for a relatively long time even the thin film transistor TFT is turned off after the video signals from the drain signal line DL are applied to the pixel electrode PX through the thin film transistor TFT.

Here, the capacitance of the capacitive element Cstg is proportional to the superposed area between the counter

electrode CT and each pixel electrode PX and hence, there is a fear that the area is increased relatively and is set to a value which exceeds a necessary value. However, since the dielectric film adopts the laminated structure formed of the insulation film GI and the protective film PSV, there is no such a fear eventually.

That is, since the insulation film GI is served to function as the gate insulation film of the thin film transistor TFT, the film thickness can not be increased. However, there is no such a restriction with respect to the protective film PSV. Accordingly, by setting the protective film PSV to a given film thickness (film thickness of only the protective film PSV being 100 nm to 4 μm, for example) together with the insulation film GI, it is possible to reduce the capacitance of the capacitive element Cstg to a given value.

It is needless to say that the protective film PSV is not limited to SiN and the protective film PSV may be formed of synthetic resin, for example. In this case, since the protective film PSV is formed by coating, it is possible to obtain an advantageous effect that even when the film thickness is to be increased, the fabricating is facilitated.

Then, on the surface of the transparent substrate on which the pixel electrodes PX and the counter electrodes CT are formed in this manner, an orientation film ORI1 is formed such that the orientation film ORI1 also covers the pixel electrode

PX and the counter electrodes CT. The orientation film ORI1 is a film which is directly brought into contact with the liquid crystal LC and determines the initial orientation direction of the liquid crystal LC.

Although the pixel electrodes PX are constituted as transparent electrodes in the above-mentioned embodiments, the pixel electrodes PX are not always transparent and may be formed of opaque metal material such as Cr. This is because that, although the numerical aperture is slightly decreased in such a case, this gives rise to no problem at all with respect to the driving of the liquid crystal LC.

Although the case in which chromium (Cr) is used as the gate signal lines GL, the counter voltage signal lines CL and the drain signal lines DL has been explained in the above-mentioned embodiments, it is needless to say that other metal of a high melting point such as Mo, W, Ti, Ta or an alloy of two or more kinds of these metals or a lamination film of two or more kinds of these metals or alloys can be used.

Further, also with respect to the transparent conductive film, although the case which uses ITO as the transparent conductive film has been explained, it is needless to say that a similar advantageous effect can be obtained by using IZO (Indium-Zinc-Oxide).

«Filter substrate»

The transparent substrate having such a constitution is

referred to as a TFT substrate and the transparent substrate which is arranged to face the TFT substrate in an opposed manner by way of the liquid crystal LC is referred to as a filter substrate.

With respect to the filter substrate, as shown in Fig. 2, on a liquid-crystal-side surface, first of all, a black matrix BM is formed such that respective pixel regions are defined, and in opening portions of the black matrix BM which substantially define the pixel regions, filters FIL are formed such that the filters FIL cover the opening portions.

Then, an overcoat film OC which is formed of a resin film, for example, is formed such that the overcoat film OC covers the black matrix BM and the filters FIL and an orientation film ORI2 is formed on an upper surface of the overcoat film.

«Overall constitution of liquid crystal display panel»

Fig. 5 is an overall constitutional view of a liquid crystal display panel showing a display region AR which is constituted of a mass of respective pixel regions which are arranged in a matrix allay.

The transparent substrate SUB2 is formed slightly smaller than the transparent substrate SUB1 and the transparent substrate SUB2 is arranged such that a right side and a lower side thereof in the drawing become substantially coplanar with corresponding sides of the transparent substrate SUB1.

Due to such a constitution, regions which are not covered

with the transparent substrate SUB2 are formed on the left side and the upper side of the transparent substrate SUB1 in the drawing. On these regions, gate signal terminals Tg which are provided for supplying scanning signals to respective gate signal lines GL and drain signal terminals Td which are provided for supplying video signals to respective drain signal lines DL are respectively formed.

The transparent substrate SUB2 is fixed to the transparent substrate SUB1 by means of sealing material SL which is formed on a periphery of the transparent substrate SUB2. This sealing material SL also functions as a seal-in material which hermetically fills the liquid crystal LC between respective transparent substrates SUB1, SUB2.

Fig. 6 shows that the liquid crystal LC which is interposed between respective transparent substrates SUB1, SUB2 is hermetically filled by means of the sealing material SL.

A liquid-crystal filling opening INJ is formed in a portion (a middle right side in Fig. 5) of the sealing material SL and this liquid-crystal filling opening INJ is sealed by a liquid crystal sealing agent not shown in the drawing after the liquid crystal is filled through the liquid crystal filling opening INJ.

«Gate signal terminals»

Fig. 7 is a constitutional view showing the gate signal

terminal GTM which is provided for supplying scanning signals to each gate signal line GL, wherein Fig. 7(a) is a plan view and Fig. 7(b) is a cross-sectional view taken along a line B-B of Fig. 7(a).

First of all, the gate signal terminal GTM which is formed of the ITO film ITO1, for example, is formed on the transparent substrate SUB1. The gate signal terminal GTM is simultaneously formed with the counter electrode CT.

The reason that the ITO film ITO1 is used as material of the gate signal terminal GTM is to make the generation of an electrolytic corrosion difficult.

Then, the gate signal line GL is formed such that the gate signal line GL covers the gate-signal-line-GL-side end portion of the gate signal terminal GTM.

Further, the insulation film GI and the protective film PSV are sequentially laminated such that these films cover the gate signal terminal GTM and the gate signal line GL, and a portion of the gate signal terminal GTM is exposed through openings formed in the protective film PSV and the insulation film GI.

Here, the above-mentioned insulation film GI and protective film PSV are formed as extension portions thereof in the display region AR.

«Drain signal terminals»

Fig. 8 is a constitutional view showing the drain signal

terminal DTM which is provided for supplying video signals to each drain signal line DL, wherein Fig. 8(a) is a plan view and Fig. 8(b) is a cross-sectional view taken along a line B-B of Fig. 8(a).

First of all, the drain signal terminal DTM which is formed on the transparent substrate SUB1 is constituted of the ITO film ITO01 which exhibits the reliable characteristic against the electrolytic corrosion and the ITO film ITO1 is simultaneously formed with the counter electrode CT.

Then, although the drain signal terminal DTM is connected with the drain signal line DL which is formed on the insulation film GI, a following drawback arises when the drain signal terminal DTM is connected with the drain signal line DL by forming the contact hole in the insulation film GI.

That is, the insulation film GI made of SiN which is formed on the ITO film becomes a whitely muddy state at a portion thereof which is brought into contact with the ITO film so that when the contact hole is formed in the portion, the contact hole is formed in an inversely-tapered shape whereby there still remains a possibility that the connection of the drain signal line DL becomes defective.

Accordingly, as shown in the drawing, a metal layer gl made of Cr, for example, is formed on an end portion of the drain signal terminal DTM in a superposed manner and the contact hole is formed on the insulation film GI formed on the metal layer

gl.

Then, in forming the contact hole, the man-hours for fabricating is decreased by forming the contact hole after forming the protective film PSV on the insulation film GI. Accordingly, the drain signal line DL and the metal layer gl are connected through the ITO film ITO2 which is formed simultaneously with the pixel electrode PX through the contact hole formed in the protective film PSV.

Here, the case in which Cr is used as the metal layer gl is shown, the metal layer gl may be made of Al or material which contains Al. In this case, since the metal layer gl is liable to be oxidized on a contact surface with the ITO film as mentioned above, it is possible to obtain the favorable connection by making the metal layer gl have the three-layered structure which forms metal layers of a high melting point on upper and lower surfaces of the metal layer gl such as Ti/Al/Ti.

«Counter voltage signal terminals»

Fig. 9 is a constitutional view which shows the counter voltage signal terminal CTM which is provided for supplying counter voltage signals to the counter voltage signal lines CL, wherein Fig. 9(a) is a plan view and Fig. 9(b) is a cross-sectional view taken along a line B-B of Fig. 9(a).

The counter voltage signal terminal CTM which is formed on the transparent substrate SUB1 is also formed of the ITO film ITO1 having the reliable characteristics against the

electrolytic corrosion and is simultaneously formed with the counter electrode CT.

Then, the counter voltage signal lines CL are formed such that the counter voltage signal line CL cover the counter voltage signal terminal CTM at a counter-voltage-signal-line-CL-side end portion.

Further, the insulation film GI and the protective film PSV which are formed as the extension portions in the display region AR are sequentially laminated on these signal lines so as to cover these signal lines and a portion of the counter voltage signal terminal CTM is exposed through openings formed in the protective film PSV and the insulation film GI.

«Equivalent circuit»

Fig. 10 is a view which shows an equivalent circuit of a liquid crystal display panel along with exteriorly mounted circuits of the liquid crystal display panel.

In Fig. 10, scanning signals (voltage signals) are sequentially supplied to respective gate signal lines GL which are extended in the x direction and are arranged in parallel in the y direction from a vertical scanning circuit V.

Thin film transistors TFT of respective pixel regions which are arranged along the gate signal lines GL to which the scanning signals are supplied are turned on by the scanning signals.

Video signals are supplied from a video signal driver

circuit H to respective drain signal lines DL at the timing which matches the above operation and the video signals are applied to the pixel electrodes PX through the thin film transistors of respective pixel regions.

In each pixel region, counter voltages are applied to the counter electrode CT which is formed along with the pixel electrodes PX through the counter voltage signal line CL so as to generate an electric field between them.

Then, the light transmissivity of the liquid crystal LC is controlled by an electric field (a lateral electric field) which has a component parallel to the transparent substrate SUB1 out of this electric field.

In the drawing, respective symbols R, G, B which indicate respective pixel regions imply that a red filter, a green filter and a blue filter are respectively formed on respective pixel regions.

«Timing chart of pixel display»

Fig. 11 is a timing chart of respective signals supplied to the liquid crystal display panel. In the drawing, VG indicates the scanning signal supplied to the gate signal line GL, VD indicates video signal supplied to the drain signal line DL, and VC indicates the counter voltage signal supplied to the counter voltage signal line CT.

Fig. 11 is a drive waveform diagram showing a general line inversion (a dot inversion) with the potential of the

counter voltage signal VC set at a fixed value.

«Liquid crystal display panel module»

Fig. 12 is a plan view which shows a module structure on which the exterior circuits are mounted on the liquid crystal display panel PNL shown in Fig. 5.

In the drawing, to the periphery of the liquid crystal display panel, the vertical scanning circuit V, the video signal driver circuit H and a power supply circuit board PCB2 are connected.

The vertical scanning circuit V is constituted of a plurality of driver IC chips which are formed in a film carrier system and output bumps thereof are connected to the gate signal terminals GTM of the liquid crystal display panel, while input bumps thereof are connected to terminals on a flexible substrate.

The video signal driver circuit H, in the same manner, are also constituted of a plurality of driver IC chips which are formed in a film carrier system and output bumps thereof are connected to the drain signal terminals DTM of the liquid crystal display panel, while input bumps thereof are connected to terminals on the flexible substrate.

The power supply circuit board PCB2 is connected to the video signal driver circuit H through a flat cable FC and the video signal driver circuit H is connected to the vertical scanning circuit V through a flat cable FC.

Here, the present invention is not limited to the above-mentioned constitution and it is needless to say that the present invention is applicable to a so-called COG (Chip On Glass) system in which semiconductor chips which constitute respective circuits are directly mounted on the transparent substrate SUB1 and respective input and output bumps of the semiconductor chips are connected to terminals (or wiring layers) which are formed on the transparent substrate SUB1.

«Fabricating method»

Fig. 13 and Fig. 14 are flow charts showing one embodiment of a fabricating method of the above-mentioned TFT substrate.

The fabrication is completed through photolithography steps (A) to (F). In respective drawings consisting of Fig. 13 and Fig. 14, the left side indicates the pixel region and the right side indicates the drain-signal-terminal forming region in the drawing.

Hereinafter, the fabricating method is explained in the order of steps.

Step (A)

The transparent substrate SUB1 is prepared and an ITO film is formed on the whole area of the surface thereof by sputtering, for example. Then, the ITO film is selectively etched by a photolithography technique so as to form the counter electrode CT on the pixel region and the drain signal terminal DTM on the drain-signal-terminal forming region.

Step (B)

A Cr film is formed on the whole area of the surface of the transparent substrate SUB1. Then, the Cr film is selectively etched by a photolithography technique so as to form the gate signal line GL and the counter voltage signal line CL on the pixel region and the conductive layer g1 which constitutes an intermediate connector on the drain-signal-terminal forming region.

Step (C)

A SiN film is formed on the whole area of the surface of the transparent substrate SUB1 by a CVD method, for example, thus forming the insulation film GI.

Further, an a-Si layer and an a-Si layer doped with n-type impurity are sequentially formed on the whole area of the surface of the insulation film GI by a CVD method, for example. Then, the a-Si layer is selectively etched using a photolithography technique so as to form the semiconductor layer AS of the thin film transistor TFT on the pixel region.

Step (D)

A Cr film is formed on the whole area of the surface of the transparent substrate SUB1 by a sputtering method, for example and the Cr film is selectively etched by a photolithography technique so as to form the drain signal line DL and the source electrode SD1 and the drain electrode SD2 of the thin film transistor TFT on the pixel region and the

extension portions of the drain signal lines DL on the drain-signal-terminal forming region.

Step (E)

A SiN film is formed on the whole area of the surface of the transparent substrate SUB1 by a CVD method, for example, thus forming the protective film PSV. Then, the protective film PSV is selectively etched by a photolithography technique so as to form the contact hole which exposes a portion of the drain electrode SD2 of the thin film transistor TFT on the pixel region and the contact hole which penetrates the protective film PSV and reaches the insulation film GI disposed below the protective film PSV and exposes a portion of the conductive layer g1 on the drain-signal-terminal forming region.

Step (F)

An ITO film ITO2 is formed on the whole area of the surface of the transparent substrate SUB1 by a sputtering method, for example. Then, the ITO film is selectively etched by a photolithography technique so as to form the pixel electrode PX which is connectd to the drain electrode SD2 of the thin film transistor TFT through the contact hole on the pixel region and the connection layer which connects the drain signal line DL and the above-mentioned conductive layer g1 on the drain-signal-terminal forming region.

In the above-mentioned fabricating method, the step (A) and the step (B) can be reversed. That is, the counter electrode

CT can be connected to the gate signal line GL from above. In this case, it is necessary to form the cross-sectional shape of the gate signal line GL into a gentle tapered shape.

On the other hand, in this system, since the counter electrodes CT are disposed below the gate signal lines GL and the counter voltage signal lines CL, the favorable connection can be obtained irrespective of the cross-sectional shape of the gate signal lines GL.

On the other hand, although the SiN film is used as the gate insulation film GI in this embodiment, the whitely muddy state of the ITO can be surely prevented so that an insulation film containing oxygen such as SiO_2 or SiON may be used at least as the gate insulation film GI which is brought into contact with ITO.

[Embodiment 2]

«Constitution of pixel»

Fig. 15 is a plan view showing another embodiment of a liquid crystal display device according to the present invention and Fig. 16, Fig. 17 and Fig. 18 are respectively a cross-sectional view taken along a line 16-16 of Fig. 15, a cross-sectional view taken along a line 17-17 of Fig. 15 and a cross-sectional view taken along a line 18-18 of Fig. 15.

Fig. 15 corresponds to Fig. 1 which shows the embodiment 1, wherein symbols which are equal to the symbols in Fig. 1 indicate the identical materials.

The constitution of this embodiment which differs from the constitution of the first embodiment is that, first of all, counter electrodes CT which are formed of transparent electrodes are formed on an insulation film GI and the counter electrodes CT and the drain signal lines DL are formed on the same layer.

This implies that the counter electrodes CT are formed as layers which are different from gate signal lines GL.

Then, conductive films FGT which are formed on a side portion of the counter electrode CT at a position close to the drain signal lines DL are formed on the same layer as the gate signal lines GL, wherein the conductive films FGT are formed in the state that the conductive films FGT are not electrically connected with the counter electrodes CT.

Accordingly, as in the case of the embodiment 1, the conductive films FGT do not function as portions of the counter voltage signal lines CL and exclusively function as light shielding materials which shield the leaking of light or the like due to liquid crystal derived from an electric field generated between the drain signal lines DL and the counter electrodes CT.

Such a constitution brings about an advantageous effect that a distance between the drain signal line DL and the counter electrode CT can be narrowed so that the numerical aperture can be enhanced.

However, it is needless to say that the conductive films FGT are not formed in such a manner and are formed on the same layer with the counter electrodes CT, and are formed such that the conductive films FGT are partially connected with side portions of the counter electrode CT in the vicinity of the drain signal lines DL.

Then, in respective pixel regions, the counter electrodes CT of respective pixel regions which are arranged along the drain signal lines DL (in the direction perpendicular to the gate signal lines GL) are connected to each other.

That is, the counter electrodes CT of respective pixel regions are integrally formed with each other astride the region where the gate signal line GL is formed.

In other words, the counter electrodes CT of respective pixel regions which are arranged along the drain signal lines DL are formed in a strip shape along the drain signal lines DL and these respective strip-like counter electrodes CT are divided by regions where the drain signal lines DL are formed.

These counter electrodes CT are formed on the layer different from the layer for the gate signal lines GL and hence, the counter electrodes CT can be formed without being connected with the gate signal lines GL.

By supplying counter voltage signals to the counter electrodes CT which are formed in such a strip shape from the outside of a display region which is formed as a mass of pixel

regions, it is possible to obtain an advantageous effect that it is unnecessary to specifically form the counter voltage signal lines CL shown in the embodiment 1.

Accordingly, by disposing the pixel electrodes PX closer to the gate signal lines GL or by extending the pixel electrodes PX to an extent that the pixel electrodes PX are superposed on the gate signal lines GL (see Fig. 15), it is possible to make the pixel electrodes PX have a function of the pixel region also in the vicinity of the gate signal lines GL.

This brings about an advantageous effect that, in the vicinity of the gate signal lines GL, it is sufficient to make the gate signal lines GL per se have the function of the black matrix (in other words, the black matrix which covers the gate signal lines GL and portions in the vicinity of the gate signal lines GL being no more necessary) so that the numerical aperture can be largely enhanced.

In the above-mentioned embodiment, among respective pixel regions, the counter electrodes CT of respective pixel regions which are arranged along the drain signal lines DL are commonly constituted. However, it is needless to say that the counter electrodes CT of respective pixel regions which are arranged along the gate signal lines GL are commonly constituted.

In this case, it is necessary that the counter electrodes CT are formed on the layer which is different from the layer

for the drain lines DL and it is applicable to the constitution of the embodiment 1.

«Fabricating method»

Fig. 19 and Fig. 20 are flow charts showing one embodiment of the fabricating method of the liquid crystal display device described in the above-mentioned embodiment. These drawings correspond to Fig. 13 and Fig. 14.

To compare with the embodiment 1, this embodiment differs from the embodiment 1 in the fabrication steps corresponding to the difference in constitution that the counter electrodes CT are formed on an upper surface of the insulation film GI and the pixel electrodes PX are formed on the counter electrodes CT by way of the protective film PSV.

[Embodiment 3]

Fig. 21 is a plan view showing another embodiment of a liquid crystal display device according to the present invention and corresponds to Fig. 15. Fig. 22 is a cross-sectional view taken along a line 22-22 of Fig. 21.

In Fig. 21, symbols which are equal to the symbols in Fig. 15 indicate the equal parts.

The portion of this embodiment which differs from the constitution shown in Fig. 15 is that, first of all, in the inside of respective pixel regions which are arranged along drain signal lines DL, counter voltage signal lines CL which run substantially in parallel with the drain signal lines DL are

formed.

The counter voltage signal lines CL are formed right below (or maybe right above) counter electrodes CT. In other words, the counter voltage signal lines CL are formed such that the counter voltage signal lines CL are connected to the counter voltages CT and are given with a function to decrease the electric resistance of the counter electrodes CT per se.

The counter voltage signal lines CL are simultaneously formed with the drain signal lines DL, for example, and are formed of the same material as the drain signal lines DL. Accordingly, the counter voltage signal lines CL are constituted of conductive layers having the electric resistance smaller than that of ITO which constitutes the counter electrodes CT.

Then, the counter voltage signal line CL runs at the center of the pixel region so as to divide the pixel region in substantially halves. This is because that the counter voltage signal line CL is formed such that the short-circuiting of the counter voltage signal line CL and the drain signal lines DL which are disposed at both sides of the pixel region can be surely avoided.

Further, the counter voltage signal line CL is formed in a superposed manner on one of the pixel electrodes PX which are formed such that the pixel electrodes PX are extended in the y direction in the drawing.

In view of the fact that the portions on which the pixel electrodes PX are formed constitute portions which cannot avoid the reduction of the light transmissivity, this embodiment is provided to minimize the reduction of the light transmissivity on the whole pixel region by positioning the counter voltage signal line CL on the portion.

In this embodiment, the ITO film ITO1 is formed on an upper surface of the drain signal line DL by lamination and even when the drain signal line DL is formed in a disconnected state, the disconnection can be repaired by the ITO film ITO1.

Since the ITO film ITO1 can be simultaneously formed at the time of forming the counter electrode CT, it is possible to obtain an advantageous effect that the increase of man-hours for fabrication can be avoided.

[Embodiment 4]

Fig. 23 is a plan view showing another embodiment of a liquid crystal display device according to the present invention and Fig. 24, Fig. 25 and Fig. 26 are respectively a cross-sectional view taken along a line 24-24 of Fig. 23, a cross-sectional view taken along a line 25-25 of Fig. 23 and a cross-sectional view taken along a line 26-26 of Fig. 23.

Fig. 23 is a view which corresponds to Fig. 1, wherein symbols which are equal to the symbols in Fig. 1 indicate the equal parts.

The constitution of Fig. 23 which differs from the

constitution of Fig. 1 is that pixel electrodes PX are formed on an insulation film GI and counter electrodes CT are formed by way of the insulation film GI. That is, the liquid-crystal-side pixel electrodes PX are arranged by way of a protective film PVS (and an orientation film ORI1).

Due to such a constitution, lines of electric force in the liquid crystal LC are increased due to the voltage division effect derived from the protective film PVS so that material having the low resistance can be selected as material of the liquid crystal LC whereby it is possible to achieve an advantageous effect that the display with a small residual image can be obtained.

Further, due to such a constitution, as shown in Fig. 25, a source electrode SD1 of a thin film transistor TFT and the pixel electrode PX can be directly connected and hence, the cumbersomeness of connection through a contact hole formed in a protective film or the like, for example, can be resolved.

[Embodiment 5]

Fig. 27 is a plan view showing another embodiment of a liquid crystal display device according to the present invention and Fig. 28, Fig. 29 and Fig. 30 are respectively a cross-sectional view taken along a line 28-28 of Fig. 27, a cross-sectional view taken along a line 29-29 of Fig. 27 and a cross-sectional view taken along a line 30-30 of Fig. 27.

Fig. 27 corresponds to Fig. 1, wherein symbols which are

equal to the symbols in Fig. 1 indicate the equal parts.

In Fig. 27, the constitution of this embodiment which differs from the constitution shown in Fig. 1 is that, first of all, pixel electrodes PX are positioned as lower layers and counter electrodes CT are positioned as upper layers by way of an insulation layer.

As shown in Fig. 28, a first protective film PSV1 is formed on an upper surface of an insulation film GI and the pixel electrode PX is formed on the first protective film PSV1.

The pixel electrode PX is constituted of a transparent electrode which is formed on a major portion excluding a periphery of the pixel region, wherein the pixel electrode PX is connected with a source electrode SD2 of a thin film transistor TFT which is formed as a layer below the first protective film PSV1 through a contact hole.

Then, a second protective film PSV2 is formed such that the second protective film PSV2 also covers the pixel electrode PX in such a manner and the counter electrode CT is formed on an upper surface of the second protective film PSV2.

The counter electrodes CT is formed of a plurality of strip-like electrodes which are extended in the y direction and are arranged in parallel in the x direction in the drawing in a region where the counter electrode CT is superposed on the pixel electrode PX. These electrodes are formed such that the electrodes have respective both ends thereof connected with

conductive layers which are integrally formed with respective counter electrodes CT over other whole areas excluding regions between respective counter electrodes CT.

In other words, the counter electrodes CT are formed such that, among the conductive layers (ITO) which are formed so as to cover at least a display region, a plurality of strip-like openings which are extended in the y direction and are arranged in the x direction in parallel in the drawing are formed in the conductive layers in the inside of regions which are superposed on the pixel electrodes PX.

This implies that the conductive layers other than the conductive layers which function as the counter electrodes CT can be utilized as the counter voltage signal lines CL. In this case, it is possible to obtain an advantageous effect that the electric resistance of the whole conductive layers can be largely decreased.

Further, the conductive layers other than the conductive layers which function as the counter electrodes CT can be formed in a state that the conductive layers cover the gate signal lines GL and the drain signal lines DL.

This implies that the conductive layers other than the conductive layers which function as the counter electrodes CT are given a function as a conventional black matrix layer.

An electric field (a lateral electric field) which has a component parallel to a transparent substrate for controlling

the light transmissivity of liquid crystal can be generated between the conductive layer which functions as the counter electrode CT and the pixel electrode PX and cannot be generated portions other than these portions.

Accordingly, as shown in Fig. 28, it is unnecessary to form the black matrix layer on the transparent substrate SUB2 side so that it is possible to obtain an advantageous effect that man-hours for fabrication can be decreased.

In this case, by adopting a so-called normally black liquid crystal which can perform a black display in a state that an electric field is not applied as the liquid crystal, it is possible to strengthen the function of the conductive layer as the black matrix.

Further, it is deniable that the gate signal lines GL or the drain signal lines DL generate capacitance between these signal lines and the above-mentioned conductive films. Accordingly, among the first protective film PSV1 and the second protective film PSV2 which are interposed between these signal lines and the conductive films, by constituting the second protective film PSV2, for example, using a resin film which can be formed by coating and by making such a resin film have a relatively large film thickness, the capacitance can be decreased.

For example, when a SiN film having a relative dielectric constant of 7 and a film thickness of 100 to 900 nm is used as

the first protective film PSV1, it is proper to use an organic film having a relative dielectric constant of 3 to 4 and a film thickness of 1000 to 3000 nm as the second protective film PSV2.

Further, when the relative dielectric constant of the second protective film PSV2 is set to equal to or less than 1/2 of the relative dielectric constant of the first protective film PSV1, it has been confirmed that no defects appear in practical products irrespective of the film thickness. Still further, when the film thickness of the second protective film PSV2 is set to twice or more of the film thickness of the first protective film PSV1, it has been confirmed that no defects appear in practical products irrespective of the relative dielectric constant.

[Embodiment 6]

Fig. 31 is a plan view showing another embodiment of a liquid crystal display device according to the present invention and Fig. 32 is a cross-sectional view taken along a line 32-32 of Fig. 31.

Fig. 31 shows a further improved constitution compared to the constitution of the embodiment 5 and symbols which are as same as the symbols used in Fig. 27 to Fig. 30 indicate identical materials.

The constitution which makes the embodiment 6 differ from the embodiment 5 is that, first of all, pixel electrodes PX are formed on an insulation film GI and counter electrodes CT are

formed on a first protective film PSV1 which is formed on the pixel electrodes PX. In other words, the pixel electrodes PX and the counter electrodes CT are formed on different layers by way of the first protective film PSV1.

On the other hand, on other regions except for the pixel regions, the second protective film PSV2 is formed. The second protective film PSV2 is formed such that, for example, the second protective film PSV2 is formed over the whole area of at least the display region and, thereafter, portions thereof which correspond to the pixel regions are selectively etched.

Further, on a surface of the remaining second protective film PSV2, a conductive layer is formed. This conductive layer is integrally formed with the counter electrodes CT. In the same manner as the fifth embodiment 5, the conductive film is formed on the whole area of at least the display region and, thereafter, in the conductive layer within regions which are superposed on the pixel electrodes PX, a plurality of strip-like openings which are extended in the y direction and are arranged in parallel in the x direction are formed thus forming the counter electrodes CT.

In the liquid crystal display device having such a constitution, it is possible to obtain following advantageous effects. That is, by interposing the first protective film PSV1 and the second protective film PSV2 between the gate signal lines GL or the drain signal lines DL and the above-mentioned

conductive layer, the capacitance which is generated between the signal lines and the conductive layer can be decreased, while by interposing only the first protective film PSV1 between the pixel electrodes PX and the counter electrodes CT, an electric field which is generated between them can be intensified at the liquid crystal LC side.

[Comparison of characteristics of respective embodiments]

Fig. 35 is a graph which shows characteristics of transmissivity relative to an applied voltage in respective constitutions of the above-mentioned embodiment 1, embodiment 2, embodiment 4, embodiment 5 and embodiment 6.

Here, the liquid crystal display devices of respective embodiments are those which satisfy a so-called 15-type XGA Regulation, wherein the devices whose width of gate signal lines GL is set to 10 μm and whose width of drain signal lines DL is set to 8 μm are subjected to the present invention.

In Fig. 35, for the comparison purpose, besides the characteristics of the above-mentioned embodiments, the characteristics of a TN-type TFT-LCD and an IPS-type TFT-LCD are also shown.

From Fig. 35, it has been confirmed that the numerical aperture becomes 60% in the embodiment 1, the numerical aperture becomes 70 % in the embodiment 2, the numerical aperture becomes 50 % in the embodiment 4, and the numerical aperture becomes 80 % in the embodiments 5 and 6.

Here, the reason that the embodiments 5 and 6 exhibit the particularly high numerical apertures is that these embodiments adopt the constitutions which make the black matrix which has been conventionally used unnecessary.

Further, the reason that the embodiment 6 can reduce the driving voltage compared to the embodiment 5 is that the embodiment 6 adopts the constitution in which the second protective film PSV2 is not formed in the pixel region.

The above-mentioned characteristics are those of elements which are prepared by using liquid crystal material having mainly negative dielectric anisotropy. On the other hand, when the liquid crystal material having positive dielectric anisotropy is used, although the maximum values of transmissivity of respective embodiments were decreased by 0.5 % respectively, an advantageous effect that a threshold value voltage is reduced by 0.5 V was obtained to the contrary.

[Embodiment 7]

Fig. 36 is a plan view showing another embodiment of the liquid crystal display device according to the present invention and shows a case in which the above-mentioned respective embodiments are applied to a so-called multi-domain system liquid crystal display device.

Here, with respect to the multi-domain system, in an electric field (a lateral electric field) which is generated in the spreading direction of the liquid crystal, regions which

differ in the direction of the lateral electric field are formed in the inside of each pixel region and by making the twisting direction of molecules of the liquid crystal in each region opposite to each other, an advantageous effect that the coloring difference which is generated when the display region is viewed from the left and the right can be offset is obtained.

Fig. 36 constitutes a view which corresponds to Fig. 1, for example. In the drawing, respective strip-like pixel electrodes PX which are extended in one direction and are arranged in parallel in the direction which intersects one direction are extended while being inclined with respect to the above-mentioned one direction by an angle θ(appropriately 5 - 40° when the liquid crystal is P-type liquid crystal and the rubbing direction of the orientation film is aligned with the direction of the drain signal lines) and thereafter respective pixel electrodes PX are bent by an angle (-2θ) and are extended and the above extensions are repeated thus forming respective pixel electrodes PX in a zigzag shape.

In this case, by forming the counter electrode CT in a region of the pixel region excluding a periphery of the pixel region and by only arranging respective pixel electrodes PX having the above-mentioned constitution to be superposed on the counter electrode CT, it is possible to obtain the advantageous effect of the multi-domain system.

Particularly, it has been confirmed that the electric

field which is generated between the counter electrode CT and the pixel electrode PX at bent portions of the pixel electrodes PX is generated exactly in the same manner between the counter electrodes CT and the pixel electrode PX at other portions of the pixel electrodes PX. Conventionally, a so-called disclination region which defines a non-transmitting portion where the twisting directions of molecules of the liquid crystal become random was generated.

Accordingly, it is possible to obtain an advantageous effect that a drawback that the light transmissivity is decreased in the vicinity of bent portions of the pixel electrodes PX can be obviated.

Here, although the pixel electrodes PX are formed by extending them in the y direction as shown in Fig. 36 in this embodiment, the pixel electrodes PX may be extended in the x direction in the drawing and bent portions are provided to these pixel electrodes PX so as to obtain the advantageous effect of the multi-domain system. Further, in this embodiment, the advantageous effect of the multi-domain system is obtained by providing the bent portions to the pixel electrodes PX.

However, in the constitution that the pixel electrodes PX are formed at least on the whole area of the pixel region except for the periphery of the pixel region and, as shown in Fig. 28, for example, the counter electrodes CT are extended in one direction and are arranged in parallel in the direction

which intersects one direction, it is needless to say that bent portions are provided to the counter electrodes so as to obtain the advantageous effect of the multi-domain system.

[Embodiment 8]

Fig. 37 is a plan view showing another embodiment of the liquid crystal display device according to the present invention and constitutes a view which corresponds to Fig. 27.

Here, in Fig. 37, a cross-sectional view taken along a line 38-38 and a cross-sectional view taken along a line 39-39 are respectively shown as Fig. 38 and Fig. 39. Parts which are indicated by symbols equal to the symbols used in Fig. 27 are constituted of the identical materials. The difference in constitution compared to Fig. 27 lies in the pixel electrodes PX.

The pixel electrode PX is constituted such that apertures are formed in portions which are superposed on the counter electrode CT while excluding a peripheral portion thereof. Accordingly, center axes of the counter electrodes CT extending in one direction are substantially aligned with center axes of the openings of the above-mentioned pixel electrode PX, wherein assuming a width of the counter electrode CT as W, a width of the opening is set to LL which is smaller than the width W.

In such a constitution, the distribution of the electric field which is generated between the pixel electrode PX and the counter electrodes CT can be generated exactly in the same

manner as that of Fig. 27.

Accordingly, it is possible to obtain an advantageous effect that by forming the openings, the capacitance between the pixel electrode PX and the counter electrodes CT can be decreased by an amount corresponding to the openings.

As mentioned above, although the capacitance between the pixel electrode PX and the counter electrodes CT is necessary to some extent to store video signals supplied to the pixel electrode PX for a relatively long time, when the capacitance is excessively increased, the brightness irregularities of display derived from the delay of signals is generated. Accordingly, by making the above-mentioned openings have a suitable size, the capacitance can be set to an optimum value.

Here, in setting the value of capacitance generated between the pixel electrode PX and the counter electrodes CT due to the openings formed in the pixel electrode PX, there may be a case that a given capacitance value cannot be obtained due to the displacement of the counter electrodes CT relative to the pixel electrode PX.

In this case, as shown in Fig. 42, for example, a pair of side portions of the opening of the pixel electrode PX (in the drawing, the sides which are parallel in the y direction in the drawing being adopted in view of the remarkable appearance of the drawback caused by the displacement) are formed in a zigzag shape, for example, so that the opening having

crest portions (projecting portions) and valley portions (recessed portions) at respective sides is formed.

When the pixel electrode PX and the counter electrode CT are arranged without the displacement as shown in Fig. 42 (a), the value of the capacitance is determined by an area on which they are superposed.

Then, even when the counter electrode CT is displaced in the x direction with respect to the pixel electrode PX as shown in Fig. 42 (b), such a superposed area is not changed so that the value of capacitance is not changed.

This is because that the relationship that when the crest portions of one side are retracted, the crest portions of the other side are projected is established.

From the above, the pattern of the opening is not limited to the above-mentioned pattern. For example, with respect to the displacement of one electrode, projecting portions which are projected towards the electrode side are formed on one of sides of the opening which intersect the direction of displacement and projecting portions which are retracted with respect to the electrode are formed on the other side of the opening.

Such a constitution does not assume the constitution of Fig. 27 as a premise thereof, and is applicable to all of the above-mentioned respective embodiments. For example, in the constitution where the counter electrodes CT are formed on the

whole area of the pixel region except for the periphery of the pixel region, the openings may be formed in portions of the counter electrode CT which are superposed on the pixel electrode PX except for the periphery of the counter electrode CT. Further, although the openings of one electrode have the periphery thereof superposed on the other electrode, it is needless to say that the openings are not always interposed on the other electrode.

[Embodiment 9]

Fig. 40 is a plan view showing another embodiment of the liquid crystal display device according to the present invention and a cross-sectional view taken along a line 41-41 is shown as Fig. 41.

Fig. 40 and Fig. 41 are views which explain an improvement of the embodiment 5 (Fig. 27 – Fig. 30), wherein a characterizing point is that a second protective film PSV2 which is constituted of a synthetic resin film, for example, has a function of spacers.

Here, the spacer are elements which support the other transparent substrate with respect to one transparent substrate side while maintaining an accurate gap and are required to make a layer thickness of liquid crystal uniform over the whole area of a display region.

In this embodiment, in regions which are superposed on portions of gate signal lines GL, for example, regions where

the spacers are formed are formed and the spacers are constituted as projecting portions which are integrally formed with the second protective film PSV2.

By setting the locations where the spacers are formed at same places in respective pixel regions, it is possible to make the layer thickness of the liquid crystal uniform over the whole area of the display region. This is because that the spacers are provided at the same places, the laminar structures of these portions become the same structure.

The spacers are formed such that, at the time of forming the second protective film PSV2, for example, first of all, a photosensitive synthetic resin film is formed with a film thickness which adds a height of the spacers, and, thereafter light is selectively irradiated such that the strong light is irradiated to the spacer forming regions and the weak light is irradiated to the regions other than the spacer forming regions and then a developing step is performed.

With respect to respective spacers formed in this manner, the spacers having the same height can be obtained with high accuracy so that it is possible to hold the gap between respective transparent substrates uniform over the whole area of the display region.

Although it is necessary to form the counter electrodes after the spacers are formed in this embodiment, even when material of the counter electrodes remains on top surfaces of

the spacers, since the electrodes are not arranged at the so-called filter substrate side, no drawback derived from the constitution is generated.

Further, although this embodiment is explained as the improvement of the embodiment 5, it is needless to say that the present invention is not limited to this embodiment.

This is because that although when it is necessary to form a synthetic resin film as a layer which is disposed close to the liquid crystal, it is possible to obtain an advantageous effect that the spacers can be formed integrally with the synthetic resin film. Even when it is unnecessary to form such a synthetic resin film, the formation of spacers which are fixed to either one of transparent substrates can make the gap between respective transparent substrates uniform with high accuracy.

[Embodiment 10]

Fig. 43 is a cross-sectional view showing another embodiment of the liquid crystal display device according to the present invention.

Fig. 43 shows a further improved constitution compared to the embodiment 5 and is another cross-sectional view taken along a line 28-28 of Fig. 27. A planer view which shows a pixel region adopts the same constitution as Fig. 27 of the embodiment 5.

The difference in constitution compared to the embodiment 1 lies in that, first of all, a protective insulation

film PSV2 which is disposed below counter electrodes CT and separates pixel electrodes PX in an insulating manner is machined such that they are dug using counter electrodes CT or counter voltage signal wirings CL as masks.

Due to such a machining, the insulation film PSV2 disposed between a drain signal line DL and the counter voltage signal line CL can be made thick and, in the same manner, the insulation film on an area where the counter electrode CT and the pixel electrode PX are directly superposed can be formed with a thick film thickness, and the insulation film PSV2 at a distance portion between the counter electrodes CT is formed with a thin film thickness.

As an advantageous effect of the above-mentioned machining, the insulation film which is formed with a thick film thickness can reduce the capacitance of a load of the thin film transistor TFT or the load capacitance of the drain signal line DL can be reduced.

On the other hand, the insulation film PSV2 formed with a thin film thickness can decrease the voltage drop derived from the insulation film between the pixel electrode PX and the counter electrode CT so that it is possible to supply the sufficient voltage to the liquid crystal and a threshold voltage of liquid crystal can be reduced.

Further, the machining of the insulation film PSV2 is performed using the counter electrodes CT as masks and hence,

the insulation film PSV2 is machined in a self-aligned manner with the counter electrode CT so that the display irregularities are extremely hardly generated.

As can be clearly understood from the explanation with reference to the embodiments 1 to 10, according to the liquid crystal display device of the present invention, the liquid crystal display device of extremely high performance can be obtained.

[Embodiment 11]

Fig. 44 is a constitutional view of a pixel region of another embodiment of the liquid crystal display device according to the present invention and is a plan view obtained by viewing one transparent substrate of a pair of transparent substrates which are arranged to face each other from the liquid crystal side by interposing liquid crystal between them. Further, Fig. 45 is a view showing a cross section taken along a line 45-45 of Fig. 44.

First of all, in Fig. 44, gate signal lines GL which are extended in the x direction and are arranged in parallel in the y direction in the drawing are formed on the transparent substrate SUB1 using chromium (Cr), for example. The gate signal lines GL form rectangular regions together with drain signal lines DL which will be explained later and these regions constitute pixel regions.

In the pixel region, along with the gate signal line GL,

a counter voltage signal line CL is formed such that the connection of the counter voltage signal line CL with the gate signal line GL and the superposition of the counter voltage signal line CL on the gate signal line GL and the drain signal line DL (formed in a later step) are avoided. Since the counter voltage signal line CL can be formed of material equal to material of the gate signal line GL, the counter voltage signal line CL is formed by the same step used for forming the gate signal line GL. As shown in Fig. 44, the counter voltage signal line CL is constituted of a strip-like conductive layer CL' which runs in the y direction in the drawing at the center of the pixel region and a frame-like conductive layer CL" which is connected with the conductive layer and is formed along the periphery of the pixel region. Such a counter voltage signal line CL is connected with the counter voltage signal lines CL in left and right pixel regions which interpose this pixel region through the counter voltage signal lines CL which are extended in the x direction. Although the counter voltage signal line CL functions as a signal line which supplies counter voltage signals to a counter electrode CT which will be explained later, the counter voltage signal line CL is also formed to have a function of a light shielding film. The function of the counter voltage signal line CL as the light shielding film is explained in detail later.

Further, over the whole area of a central portion of the

pixel region except for a trivial peripheral portion of the pixel region, the counter electrode CT which is made of ITO1 (Indium-Tin-Oxide), for example, and constitutes a transparent conductor is formed. In this embodiment and embodiments 12 to 15 which will be explained later, a profile of the counter electrode CT (ITO1) which is formed of a transparent conductor mounted on a substrate main surface side is depicted with a bold line. The counter electrode CT (ITO1) is partially covered with other transparent conductor films (pixel electrodes PX (ITO2)) which are disposed away from the main surface of the substrate. As the transparent conductor, in place of ITO used in this embodiment, a conductive film which is formed such that the film can irradiate an incident light with a sufficient intensity (for example, a film which is capable of transmitting at least 60 % of an incident light) such as a metal thin film made of IZO (Indium-Zinc-Oxide) or formed by ion coating, for example, may be used.

The counter electrode CT is formed such that a peripheral portion of the counter electrode CT is directly superposed on an inner peripheral portion of the frame-like conductive layer of the above-mentioned counter voltage signal line CL. Due to such a constitution, the counter voltage supplied from the counter voltage signal line CL is applied to the counter electrode CT. An insulation film GI which is made of SiN, for example, is formed on the whole area of an upper surface of the

transparent substrate SUB1 such that the insulation film GI also covers the gate signal lines GL, the counter voltage signal lines CL and the counter electrodes CT. The insulation film GI is configured to perform a function of an interlayer insulation film between the counter voltage signal lines CL and the gate signal lines GL with respect to the drain signal line DL which will be explained later, to perform a function of a gate insulation film of thin film transistors TFT which will be described later in regions where the thin film transistors TFT are formed, and to perform a function of a dielectric film in regions in which capacitive elements Cstg which will be described later are formed.

As shown at a left lower portion of Fig. 44, on the above-mentioned insulation film GI at a portion of the thin film transistor TFT which is partially superposed on the gate signal line GL, a semiconductor layer AS made of a-Si, for example, is formed.

By forming a source electrode SD2 and a drain electrode SD1 on an upper surface of the semiconductor layer AS, an MIS-type transistor of an inverse stagger structure which uses a portion of the gate signal line GL as the gate electrode is formed. Then, the source electrode SD2 and the drain electrode SD1 are formed simultaneously with the drain signal line DL.

That is, the drain signal lines DL which are extended in the y direction and are arranged in parallel in the x direction

in Fig. 44 are formed and a portion of the drain signal line DL is extended over a surface of the above-mentioned semiconductor layer AS so as to constitute the drain electrode SD1 of the thin film transistor TFT.

Further, at the time of forming the drain signal lines DL, the source electrodes SD2 are formed and these source electrodes SD2 are extended over portions in the inside of the pixel regions so that contact portions which connect the source electrodes SD2 and the pixel electrodes PX which will be explained later are integrally formed with the source electrodes SD2.

Here, on an interface between the above-mentioned source electrode SD2 and drain electrode SD1 of the semiconductor layer AS, contact layers d0 which are doped with n-type impurity, for example, is formed.

The contact layers d0 are formed such that an n-type impurity doping layer is formed on the whole area of the surface of the semiconductor layer AS, the source electrode SD2 and the drain electrode SD1 are formed and, thereafter, by using the respective electrodes as masks, the n-type impurity doping layer on the surface of the semiconductor layer AS which is exposed from these respective electrodes is etched.

Here, in this embodiment, the semiconductor layers AS are formed not only in the regions where the thin film transistors TET are formed but also at portions where the gate

signal lines GL and the counter voltage signal lines CL intersect each other with respect to the drain signal lines DL. This constitution is provided for strengthening the function of the semiconductor layers AS as the interlayer insulation film.

Then, on the surface of the transparent substrate SUB1 on which the thin film transistors TFT are formed, a protective film PSV made of SiN, for example, is formed such that the protective film PSV also covers the thin film transistors TFT. The protective film PSV is provided for avoiding the direct contact of the thin film transistors TFT with the liquid crystal LC.

Further, on an upper surface of the protective film PSV, pixel electrodes PX which are formed of transparent conductive films made of ITO (Indium-Tin-Oxide), for example, are formed.

Then, the pixel electrode PX has a portion thereof connected to an extension portion of the source electrode SD2 of the thin film transistor TFT through a contact hole formed in the above-mentioned protective film PSV.

The pixel electrode PX is constituted of a plurality of first electrodes PX′ having bent portions on the counter voltage signal line CL′ which is extended in the y direction in the drawing at the substantially central portion of the pixel region and a frame-like second electrode PX″ which respectively connects respective ends of these first electrodes PX′. In

other words, these electrodes are configured such that the first electrodes PX' are arranged at an equal distance in the y direction in the drawing having an inclination of ($-\theta : \theta < 45°$) with respect to the counter electrode signal line CL' in one pixel region side defined by the counter electrode signal line CL' and, the first electrodes PX' are arranged at an equal distance in the y direction in Fig. 44 having an inclination of ($+\theta$: $\theta < 45°$) with respect to the counter electrode signal line in the other pixel region side, and corresponding electrodes in respective pixel regions are connected to each other on the counter electrode signal line CL'.

The provision of the bent portions to the first electrodes CL' means that the liquid crystal display device adopts the multi-domain system in which the directions of electric fields which the pixel electrodes having one inclination ($-\theta$) and the pixel electrodes having the other inclination ($+\theta$) respectively generate with respect to the counter electrodes CT are made different from each other so that the twisting directions of the liquid crystal molecules are made opposite to each other whereby it is possible to obtain an advantageous effect that the coloring difference which is generated when the display region is respectively viewed from the left and right sides can be offset.

Respective bent portions of the first electrodes PX' are positioned such that the bent portions are superposed on the

signal line CL' which is extended in the y direction at the center of the pixel region out of the above-mentioned counter voltage signal line CL.

In the vicinity of bent portions of the first electrodes PX', the directions of the electric fields become random so that an opaque region (hereinafter this region being referred to as "disclination region") to which a strict lateral electric field is not applied is generated. Accordingly, this embodiment adopts the constitution which shields the region from light by using the signal line CL'.

Further, with respect to the above-mentioned first electrode PX', an opening angle of electrodes with respect to the bent portions as the center is set to 2θ ($< 90°$) and hence, the opening angle assumes an acute angle.

In such a case, a relatively strong electric field is liable to be generated between the first electrodes PX' and the counter electrode CT at these bent portions so the liquid crystal molecules are rotated at a high speed. Accordingly, using these bent portions as starting points, the high-speeding of the rotation of the liquid crystal molecules can be propagated to peripheries of the bent portions and further to the whole area of the pixel region whereby it is possible to obtain an advantageous effect that a display which can promote the rapid response is achieved.

Further, out of the pixel electrodes PX, the second

electrode PX″ is constituted of a frame-like electrode PX″ which is superposed on the inner peripheral portion of the signal line CL″ which is formed in a frame-like shape out of the above-mentioned counter voltage signal line CL. The second electrode PX″ is connected with extension ends of the above-mentioned first electrodes PX′.

Between portions of the second electrode PX″ extending in the y direction in Fig. 44 and the drain signal lines DL which are disposed adjacent to these portions, the above-mentioned counter voltage signal lines CL″ are formed such that they are extended in the y direction in the drawing.

The counter voltage signal lines CL″ are formed with a wide width such that gaps between the drain signal lines DL and the counter voltage signal lines CL″ can be made as small as possible.

In other words, gaps formed between the electrodes PX″ which are extended in the y direction in Fig. 44 out of the pixel electrodes PX and the drain signal lines DL which are disposed adjacent to the electrodes PX″ are shielded from light by means of the counter voltage signal lines CL″.

Such a constitution is adopted due to following reasons. That is, an electric field is generated from the drain signal line DL in response to video signals which are supplied to the drain signal line DL. This electric field is terminated at the counter voltage signal line CL″ side and the light transmission

due to the change of the light transmissivity of liquid crystal which is changed by the electric field is shielded.

The pixel electrodes PX having such a constitution can achieve following various advantageous effects.

First of all, since the regions which differ in the directions of electric fields generated between the pixel electrodes PX and the counter electrodes CT are formed by dividing the pixel region in halves, each pixel electrode PX (first pixel electrode PX′) has one bent portion so that the total number of bent portions become the number of the first pixel electrodes PX′.

In a conventional liquid crystal display device, for example, respective pixel electrodes which are extended in the y direction and are arranged in parallel in the x direction in Fig. 44 are inclined in the right side along the longitudinal direction and then are inclined in the left side along the longitudinal direction and these inclinations are repeated to form the pixel electrodes in the zigzag shape. Compared to such a conventional liquid crystal display device, this embodiment can provide the constitution which largely reduces the bent portions of the electrodes.

Accordingly, it is possible to largely reduce the generation of the disclination region at the bent portions of the electrodes PX′.

Further, by newly providing the second electrode PX″

which is arranged in the frame shape in the periphery of the pixel region besides the above-mentioned first electrode PX', the pixel electrode PX can generate the lateral electric field also between the second electrode PX" and the counter electrodes CT.

Conventionally, with respect to the pixel electrodes in the zigzag shape, a small space and a large space are alternately formed between the pixel electrode and the drain signal lines disposed close to the pixel electrode and hence, so-called dead spaces where a sufficient lateral electric field is not generated have been formed in the large spaces.

Accordingly, by adopting the constitution of this embodiment, the above-mentioned generation of the dead spaces can be suppressed so that it is possible to perform the substantial enlargement of the pixel region.

Here, the second electrode PX" also has a function of supplying video signals to respective first electrodes PX' through the source electrode SD2 of the thin film transistor TFT.

Accordingly, it is needless to say that, so long as this function is satisfied, it is not always necessary to form the second electrode PX" in a frame-like shape along the periphery of the pixel region.

For example, with respect to the second electrode PX" of Fig. 44, even when the upper-side (side opposite to the thin

film transistor TFT) portion in the drawing out of the portions extending in the x direction in parallel in the drawing is not particularly formed, it is possible to obtain a sufficient advantageous effect. On the surface of the transparent substrate SUB1 on which the pixel electrodes PX are formed in this manner, an orientation film (not shown in Fig. 44 and Fig. 45, see embodiment 1) is formed such that the orientation film also covers the pixel electrode PX. This orientation film is a film which is subjected to the rubbing treatment in the y direction in the drawing and is brought into direct contact with a liquid crystal LC so that the orientation film can determine the initial orientation direction of the liquid crystal LC.

Although the pixel electrodes PX are constituted as the transparent electrodes in the above-mentioned embodiment, the pixel electrodes PX are not always transparent and may be formed of opaque metal material such as Cr, for example. This is because that although the numerical aperture is slightly decreased due to such a constitution, this gives rise to no defects in driving of the liquid crystal LC.

Further, the transparent substrate SUB1 having such a constitution is referred to as a so-called TFT substrate and the transparent substrate which is arranged to face this TFT substrate in an opposed manner while sandwiching the liquid crystal LC therebetween is referred to as a filter substrate. On a liquid-crystal-side surface of the filter substrate, first

of all, a black matrix is formed so as to define respective pixel regions and filters are formed such that the filters cover opening portions of the black matrix which substantially determine the pixel regions. Then, an overcoat film made of a resin film, for example, is formed such that the overcoat film covers the black matrix and the filters, and an orientation film is formed on an upper surface of the overcoat film. The detail of these components are exactly as same as those described in the embodiment 1.

[Embodiment 12]

Fig. 46 is a view which shows another embodiment of the liquid crystal display device according to the present invention and constitutes a view which corresponds to Fig. 1. Further, Fig. 47 is a view which shows a cross-section taken along a line 47-47 in Fig. 46.

The constitution of this embodiment which differs from the constitution shown in Fig. 44 is that, first of all, as a member which shields portions in the vicinity of bent portions of pixel electrodes PX having the bent portions from light, a conductive layer CL which is formed along with drain signal lines GL is used (accordingly, the conductive layer CL uses the same material as the signal lines).

The conductive layer CL constitutes a counter voltage signal line LC and hence, a counter electrode CT which is constituted of a transparent electrode is formed in an

superposed manner on an upper layer (or on a lower layer if necessary) of the counter voltage signal line LC.

Further, since the conductive layer GL′ is formed such that the conductive layer GL′ runs in the y direction at the approximately center of the pixel region, the conductive layer GL′ can be formed without any fear of being short-circuited with respective drain signal lines GL which are positioned at both sides of the conductive layer GL′.

[Embodiment 13]

Fig. 48 is a view which shows another embodiment of the liquid crystal display device according to the present invention and constitutes a view which corresponds to Fig. 44.

The difference in constitution between this embodiment and the embodiment shown in Fig. 44 lies in the constitution of pixel electrodes PX, wherein in place of portions of a frame-like second electrode PX″ to which respective end portions of a plurality of first electrodes PX′ having bent portions are respectively connected and are extended in the y direction in the drawing, a third electrode PX3 which is extended in the y direction in the drawing at the center portion of the pixel electrode is provided.

Even when the liquid crystal display device is constituted in such a manner, it is possible to form the pixel electrodes over the whole area of the pixel region without dead spaces.

[Embodiment 14]

Fig. 49 is a view showing another embodiment of the liquid crystal display device according to the present invention and constitutes a view which corresponds to Fig. 44.

The constitution of this embodiment which differs from the constitution of Fig. 44 lies in that the pixel region is divided in halves into regions which differ in the direction of electric field by a boundary which is parallel to the x direction in the drawing.

Accordingly, this embodiment adopts a pattern in which pixel electrodes PX (first electrodes PX') having bent portions are arranged with an angle of ($-\phi$: $\phi > 45°$) with respect to the x direction in the drawing in one pixel region and the pixel electrodes PX are arranged with an angle of ($+\phi$: $\phi > 45°$) with respect to the x direction in the drawing in the other pixel region, and the corresponding pixel electrodes are connected each other at the boundary portion.

Even in such a case, it is possible to narrow dead spaces and to decrease the number of the bent portions of the first electrodes PX' of the pixel electrodes.

Further, in such a case, in view of the optimum setting of the initial orientation direction (the y direction in the drawing) of an orientation film and the directions of respective electric fields, an opening angle (2 ϕ) at the bent portions of the first electrodes can be set to an obtuse angle.

Accordingly, it is possible to decrease the generation of so-called disclination regions at the bent portions of the pixel electrodes (first electrodes).

As described above, in this embodiment, although light shielding means are not provided to the bent portions of respective pixel electrodes, it is needless to say that light shielding means may be provided to achieve the complete prevention of generation of the disclination regions.

Here, it is needless to say that, in Fig. 49, with respect to the second electrode PX", even when the upper side (the side opposite to the thin film transistor TFT) portion in the drawing among portions which are positioned parallel to the x direction in the drawing is not particularly formed, a sufficient advantageous effect can be obtained.

[Embodiment 15]

Fig. 50 is a view showing another embodiment of the liquid crystal display device according to the present invention and constitutes a view corresponding to Fig. 44.

The difference of this embodiment from the embodiment of Fig. 44 in constitution lies in the connection of a counter voltage signal line CL and the counter electrode CT. In this embodiment, gate signal lines GL use chromium (Cr) based alloy, wherein after forming the gate signal lines GL on a substrate by patterning, the counter electrodes CT (ITO1) are formed before forming a gate insulation film GI made of SiNx. For

example, in Fig. 13, the step (B) comes before the step (A) (the order of the step (A) and the step (B) is reversed). ITO films which constitute the counter electrodes CT are directly brought into contact with Cr films which constitute the counter voltage signal lines CL at the centers of the pixels defined by openings of the black matrix BM (profiles thereof being indicated by broken lines).

In Fig. 50, the applying direction of an electric field which rotatably drives liquid crystal molecules for modulating the light transmissivity of a liquid crystal layer, the direction of the electric field which is leaked from a drain signal line (also referred to as a video signal line, a data line) to the above-mentioned pixel (the region surrounded by a frame indicated by a broken line BM), and the advancing direction of a rubbing roller (so-called rubbing direction) at the time of performing the rubbing treatment on an orientation film (not shown in the drawing) which covers the illustrated electrode structure are respectively indicated by arrows of bold lines.

In this embodiment, the electric field which rotatably drives the liquid crystal molecules is applied in the up-and-down direction of the drawing (the extension direction of the drain signal line DL).

Accordingly, the influence which the electric field (lines of electric force) which is leaked from the drain signal

line to the pixel in the left-and-right direction in the drawing given to the rotation driving of the liquid crystal molecules is reduced so that the degradation of the image quality derived from longitudinal smear can be suppressed. The larger an angle which is formed by the intersection of the direction of the electric field which rotatably drives the liquid crystal molecules (arrow of "electric field applying direction to the liquid crystal") and the direction of the electric field which is leaked from the drain signal line DL to the pixel (arrow indicating "electric field direction from the drain line"), the above-mentioned generation of longitudinal smear can be suppressed more efficiently. When this intersecting angle is small, it is necessary to shield the leaking of the electric field from the drain signal line DL to the pixel by providing a counter electrode CT or a pixel electrode PX along the drain signal line DL between the drain signal line DL and the pixel. However, in this embodiment, since the pixel electrodes PX (ITO2) which are arranged in a comb shape are arranged to intersect the drain line with a sufficiently large angle, such a shielding structure is unnecessary. This feature is observed at a left upper portion and a right lower portion of the pixel shown in Fig. 50 and is served for increasing the aperture ratio of the pixel per se (area which can transmit light modulated by the rotation driving of the liquid crystal molecules).

Further, according to this embodiment, it is possible

to increase the degree of freedom of designing of the electrode structure which is constituted of the other transparent conductive film ITO2 (also referred to as "upper ITO layer" in view of the cross-sectional structure thereof) which is formed apart from one transparent conductive film ITO1 as viewed from a main surface of the substrate. Accordingly, it is possible to design the whole pixel such that the voltage signals supplied from the drain signal line DL can be applied to the pixel electrodes PX along the line which intersects (preferably intersecting at a right angle) the extension direction of the drain signal line DL.

In this embodiment, since the extension direction of combs of the pixel electrodes PX does not intersect the drain signal line DL at a right angle, the rubbing direction (the liquid crystal molecules which are in the state that the electric field is not applied to the liquid crystal modules being oriented in the direction along this direction) can be set in the direction which intersects the drain signal line at a right angle.

In the above-mentioned embodiments 11 to 14, the counter electrode CT is formed such that the counter electrode CT is extended over the whole area of the central portion of the pixel region except for the trivial periphery of the pixel region.

However, even when the counter electrode CT is not formed at portions which are superposed on the pixel electrodes PX,

this does not give any influence to the operation of the liquid crystal. Accordingly, it is needless to say that the counter electrode CT can be formed in this manner.

Further, in the above-mentioned respective embodiments, the transparent electrode which is formed over the whole area of the central portion of the pixel region except for the trivial periphery of the pixel region is formed as the counter electrode CT and the electrodes provided with the bent portions are formed as the pixel electrodes PX. However, the present invention is not limited to such a constitution. That is, it is needless to say that the transparent electrode which is extended over the whole area of the central portion of the pixel electrode except for the trivial periphery of the pixel region is formed as the pixel electrode PX and the electrodes provided with the bent portions are formed as the counter electrodes CT.

As can be clearly understood from the explanation which has been made with reference to the embodiments 11 to 14, according to the liquid crystal display device of this embodiment, the display of images having an excellent quality can be realized.

Claims

1. A liquid crystal display device being characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on each pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, an electric field having a component parallel to said transparent substrates is generated between these respective electrodes, one electrode out of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around the other electrode and is not superposed on the other electrode, and said insulation film has a multi-layered structure.

2. A liquid crystal display device according to claim 1, wherein said liquid crystal display device includes thin film transistors which are driven by the supply of scanning signals and supplies video signals to said pixel electrodes by said driving, and

said insulation film is formed of a sequential laminated body which comprises an insulation film which constitutes a portion of a gate insulation film of said thin film transistor and a protective film which avoids a direct contact of said thin film transistor with liquid crystal.

3. A liquid crystal display device according to claim

1, wherein one electrode out of said pixel electrode and said counter electrode is formed at least in a region of said pixel region except for a periphery of said pixel region, and the other electrode is formed of a plurality of electrodes which are extended in one direction in a superposed manner on said one electrode and are arranged in the direction which intersects said one direction.

4. A liquid crystal display device being characterized in that

to each liquid-crystal-side pixel region of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal,

a thin film transistor which is driven by the supply of scanning signals from a gate signal line, a pixel electrode to which video signals from a drain signal line are supplied through said thin film transistor, and a counter electrode which generates an electric field containing a component along a surface of said transparent substrate between said counter electrode and said pixel electrode are provided,

said pixel electrode and said counter electrode are formed such that an insulation film is interposed between said electrodes, and at least one of said electrodes is constituted of a transparent electrode formed on a region which is disposed around the other electrode and is not superposed on at least

said one electrode, and

said insulation film is constituted of a sequential laminated body which comprises a first insulation film which functions as a gate insulation film of said thin film transistor and a second insulation film which determines a capacitance value between said pixel electrode and said counter electrode along with said first insulation film.

5. A liquid crystal display device according to claim 4, wherein said gate insulation film is constituted of a laminated structure which is made of SiO_2 mounted on said counter electrode and SiN which is formed on said SiO_2.

6. A liquid crystal display device being characterized in that, on a liquid-crystal-side surface of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, a signal line is formed between respective pixel regions which are disposed close to each other,

in said each pixel region, one electrode out of a pair of electrodes which differ in layer is provided with an electrode forming region on which a transparent electrode formed in a region which is disposed around the other electrode and not superposed on at least said one electrode is arranged, and

within a periphery of said electrode forming region, on a side portion which is disposed close to said signal line, a

layer having smaller light transmittivity than said transparent electrode is formed.

7. A liquid crystal display device being characterized in that in each pixel region which is arranged along a drain signal line, a pixel electrode to which video signals from said drain signal line are applied through a switching element and a counter electrode which generates an electric field containing at least a component parallel to a spreading direction of liquid crystal between said counter electrode and said pixel electrode are provided,

said counter electrode is formed on a layer different from a layer on which said pixel electrode is formed and is constituted of a transparent electrode formed in a region which is disposed around said pixel electrode and is not superposed on said pixel region, and

a conductive layer which is made of material having smaller light transmissivity than said counter electrode is formed on a side portion which is disposed close to said drain signal line.

8. A liquid crystal display device according to claim 7, wherein said pixel electrode and said conductive layer are connected to each other.

9. A liquid crystal display device according to claim 7, wherein said pixel electrode and said conductive layer are arranged by way of an insulation layer.

10. A liquid crystal display device in which each pixel region of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal includes a switching element, a pixel electrode and a counter electrode, and

an electric field is generated between said pixel electrode and said counter electrode by applying video signals from a drain signal line to said pixel electrode by way of said switching element, wherein

the improvement being characterized in that said counter electrode is formed on a layer different from a layer on which said pixel electrode is formed, and is constituted of a transparent electrode formed on a region which is disposed around said pixel electrode and is not superposed on at least said pixel electrode,

on a side portion disposed close to said drain signal line, a light shielding conductive layer which is connected to said side portion is formed, and

said conductive layer constitutes a portion of a counter voltage signal line which supplies counter voltage signals to a counter electrode of a neighboring pixel region.

11. A liquid crystal display device in which each pixel region of one transparent substrate out of respective transparent substrates which are arranged to face each other

in an opposed manner by way of liquid crystal includes a switching element, a pixel electrode and a counter electrode, and

an electric field is generated between said pixel electrode and said counter electrode by applying video signals from a drain signal line to said pixel electrode by way of said switching element, wherein

the improvement being characterized in that said counter electrode is formed on a layer different from a layer on which said pixel electrode is formed, and is constituted of a transparent electrode formed on a region which is disposed around said pixel electrode and is not superposed on at least said pixel electrode, and

a conductive layer which is made of Al or material containing Al is superposed on a side portion of said counter electrode as a lower layer disposed close to said drain signal line by way of a metal layer of a high melting point.

12. A liquid crystal display device according to claim 11, wherein said metal layer of a high melting point is formed of a metal layer which includes one selected from a group consisting of Ti, Cr, Mo, Ta and W.

13. A liquid crystal display device being characterized in that said liquid crystal display device includes a signal terminal and a signal line with an insulation film disposed therebetween, wherein said signal terminal is constituted of

a first transparent metal layer and is formed as a layer below an insulation film and said signal line is formed as a layer above said insulation film,

a first metal layer other than a transparent metal layer is formed on a portion of said signal terminal in a superposed manner, and an electrical connection between said signal terminal and said signal line is established through a contact hole formed in said insulation film which exposes a portion of said first metal layer.

14. A liquid crystal display device according to claim 13, wherein a protective film is formed on said insulation film such that said protective film covers said signal line, and a second transparent metal layer which is served for connecting said first metal layer and said signal line through a contact hole which exposes a portion of said first metal layer and a contact hole which exposes a portion of said signal line is formed on said protective film.

15. A liquid crystal display device according to claim 14, wherein said first metal layer is made of Al or material containing Al and has a multi-layered structure which provides a metal layer of a high melting point on portions of upper and lower surfaces of said first metal layer which are at least respectively connected to said first transparent metal layer and said second transparent metal layer.

16. A liquid crystal display device being characterized

in that, on a liquid-crystal-side surface of one transparent substrate out of transparent substrates which are arranged to face each other by way of liquid crystal, first signal lines which are extended in one direction and are arranged in parallel and second signal lines which are extended in the direction which intersects said first signal line by way of an interlayer insulation film and are arranged in parallel are formed,

each pixel region which is surrounded by said signal lines includes a pixel electrode to which, by way of a switching element which is driven by the supply of scanning signals from one signal line out of said first signal line and said second signal line, video signals are supplied from the other signal line, and a transparent counter electrode which is formed on a layer different from a layer on which said pixel electrode is formed and is formed on a region which is disposed around said pixel electrode and is not superposed on at least said pixel region,

an electric field is generated in a spreading direction of said liquid crystal between said pixel electrode and said counter electrode, and

said counter electrodes of said respective pixel regions intersect either one of said first signal line and said second signal line which are formed on a layer different from a layer on which said counter electrode is formed and are connected to each other in common.

17. A liquid crystal display device according to claim 16, wherein counter voltage signals are supplied to said respective counter electrodes which are connected in common from the outside of a display region which is a mass of said respective pixel regions.

18. A liquid crystal display device being characterized in that each pixel region which is formed on liquid-crystal-side surfaces of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal includes a pixel electrode and a counter electrode which generate an electric field containing a component parallel to said transparent substrates,

said counter electrode is formed on a layer different from a layer on which said pixel electrode is formed and is constituted of a transparent conductive layer formed in a region which is disposed around said pixel electrode and is not superposed on said pixel electrode,

said each pixel region includes a counter voltage signal line which runs at the approximately center of each of said pixel regions arranged in parallel in one direction and is formed in an superposed manner on said counter electrode, and

said counter voltage signal line is made of material having smaller resistance than said counter electrode.

19. A liquid crystal display device according to claim 18, wherein said pixel electrode is constituted of a plurality

of electrodes which are extended in one direction and are arranged in parallel in the direction which intersects said one direction and said respective pixel electrodes are arranged to be superposed on said counter electrode, and

said counter voltage signal line is extended in said one direction such that said counter voltage signal line is superposed on one of said respective pixel electrodes

20. A liquid crystal display device according to claim 18, wherein a drain signal line which supplies video signals to said pixel electrode by way of a switching element is provided to each of said pixel regions which are arranged in parallel in said one direction, and

a layer which is formed of the same material as said counter electrode is laminated to said drain signal line.

21. A liquid crystal display device being characterized in that pixel regions which are surrounded by neighboring gate signal lines and neighboring drain signal lines are formed on a liquid-crystal-side surface of one transparent substrate out of transparent substrates which are arranged to face each other by way of liquid crystal,

a pixel electrode and a counter electrode which are arranged in different layers and generate an electric field which is extended in a spreading direction of said liquid crystal are provided in the inside of said pixel region, and

either one of said pixel electrode and said counter

electrode is formed on a layer which is different from a layer on which said gate signal line and said drain signal line are formed, and openings are formed in at least a transparent conductive layer which is formed on the whole area of a display region which is a mass of said pixel regions.

22. A liquid crystal display device according to claim 21, wherein said openings formed in said conductive layer are formed such that said openings are extended along the extension direction of said drain signal line and are arranged in parallel in the direction which intersects said extension direction.

23. A liquid crystal display device according to claim 21, wherein electrodes which are formed by forming said openings in said transparent conductive layer formed on the whole area of said display region constitute counter electrodes and said counter electrodes are formed on a layer at a side disposed closer to said liquid crystal than said pixel electrode.

24. A liquid crystal display device according to claim 21, wherein said conductive layer has functions of a counter voltage signal line and a black matrix together with a function of said counter electrode.

25. A liquid crystal display device according to claim 24, wherein said insulation film is formed of a sequential laminated body consisting of a first insulation film and a second insulation film, wherein said second insulation film has a relative dielectric constant which is equal to or less than

1/2 of a relative dielectric constant of said first insulation film or a film thickness of said second insulation film is twice or more larger than a film thickness of said first insulation film.

26. A liquid crystal display device being characterized in that pixel regions which are surrounded by neighboring gate signal lines and neighboring drain signal lines are formed on a liquid-crystal-side surface of one transparent substrate out of transparent substrates which are arranged to face each other by way of said liquid crystal,

a pixel electrode and a counter electrode which are arranged in different layers and generate an electric field which is extended in a spreading direction of said liquid crystal are provided in the inside of said pixel region, and

a conductive layer is formed on at least either one of said gate signal line and said drain signal line by way of an insulation film.

27. A liquid crystal display device according to claim 26, wherein said conductive layer is formed on a layer on which either one of said pixel electrode and said counter electrode is formed and is formed of the same material as said electrode.

28. A liquid crystal display device being characterized in that pixel regions which are surrounded by neighboring gate signal lines and neighboring drain signal lines are formed on a liquid-crystal-side surface of one transparent substrate out of

of transparent substrates which are arranged to face each other by way of said liquid crystal,

a pixel electrode and a counter electrode which are arranged by way of a first insulation film and generate an electric field which is extended in a spreading direction of said liquid crystal are provided in the inside of said pixel region, and

a second insulation film which has openings formed in portions of said pixel region and covers at least one of said gate signal line and said drain signal line is formed on said first insulation film and a conductive layer is formed on a surface of said second insulation film.

29. A liquid crystal display device according to claim 28, wherein said second insulation film has a relative dielectric constant which is equal to or less than 1/2 of a relative dielectric constant of said first insulation film or a film thickness of said second insulation film is twice or more larger than a film thickness of said first insulation film.

30. A liquid crystal display device according to claim 28, wherein said conductive film is integrally formed with either one of said pixel electrode and said counter electrode and said electrodes are formed by forming openings in said conductive film which is formed on the whole area of a display region which is a mass of said pixel region.

31. A liquid crystal display device characterized in that

a pair of electrodes which generate an electric field in a spreading direction of liquid crystal are formed on each pixel region on a liquid-crystal-side surface of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of said liquid crystal,

a pair of said electrodes are formed in different layers and said one electrode is formed of a transparent electrode formed in a region which is disposed around said other electrode and is not superposed on at least said one electrode, and

said other electrode is formed in a pattern which constitutes a region which makes the direction of an electric field which is generated between said other electrode and said one electrode different.

32. A liquid crystal display device characterized in that a pair of electrodes which generate an electric field in a spreading direction of liquid crystal are formed on each pixel region on a liquid-crystal-side surface of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of said liquid crystal,

a pair of said electrodes are formed in different layers and said one electrode is formed of a transparent electrode formed in a region which is disposed around said other electrode and is not superposed on at least said one electrode, and

said other electrode is formed in a zigzag shape by repeating the extending of said other electrode while inclining the other electrode by an angle θ with respect to one direction and the subsequent extending of said other electrode while bending the other electrode by an angle of (-2θ).

33. A liquid crystal display device characterized in that a pair of electrodes which generate an electric field which is parallel to said transparent substrate are formed on each liquid-crystal-side pixel region of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal,

a pair of said electrodes are formed in different layers,

out of a pair of said electrodes, one electrode is constituted of a plurality of electrodes which are extended in one direction and are arranged in parallel in the direction which intersects said one direction, and

said other electrode is formed of a transparent electrode which has openings at regions which are superposed on said one electrode and is formed on at least regions excluding a periphery of said pixel region.

34. A liquid crystal display device according to claim 33, wherein a periphery in which openings of said other electrode are formed is superposed on said one electrode.

35. A liquid crystal display device according to claim 33, wherein said openings of said other electrode are formed

in a pattern which respectively repeats irregularities on respective sides parallel to the longitudinal direction of said openings.

36. A liquid crystal display device characterized in that a plurality of insulation films are laminated to a liquid-crystal-side surface of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, and

out of said insulation films, on said insulation film at a side disposed close to said liquid crystal, projecting bodies which hold a gap between said one transparent substrate and said other transparent substrate are integrally formed.

37. A liquid crystal display device according to claim 36, wherein said insulation film disposed close to said liquid crystal is constituted of a resin film having photo-curing characteristics.

38. A liquid crystal display device characterized in that, to each liquid-crystal-side pixel region of one transparent substrate out of respective transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, a thin film transistor driven by the supply of scanning signals from a gate signal line, a pixel electrode to which video signals from a drain signal line are supplied by way of said thin film transistor, and a counter electrode which generates an electric field in the direction parallel to said transparent

substrates between said counter electrode and said pixel electrode are provided,

said pixel electrode and said counter electrode are formed in different layers, wherein said one electrode is constituted of a transparent electrode formed in a region which is disposed around said other electrode and is not superposed on at least said one electrode are provided,

said liquid crystal device includes a first insulation film which performs the interlayer insulation between said gate signal line and said drain signal line, a second insulation film which is formed such that said second insulation film covers said thin film transistor, and a third insulation film which performs the interlayer insulation between said pixel electrode and said counter electrode, and

projecting bodies which hold a gap between said one transparent substrate and said other transparent substrate are integrally formed with said third insulation film.

39. A liquid crystal display device according to claim 38, wherein said third insulation film is constituted of a resin film having photo-curing characteristics.

40. A liquid crystal display device according to claim 38, wherein liquid crystal material having negative dielectric anisotropy is used as said liquid crystal.

41. A liquid crystal display device according to claim 38, wherein said gate signal line or said drain signal line is

constituted of material containing at least one of Mo, Cr, Ti, Ta, W.

42. A liquid crystal display device according to claim 38, wherein liquid crystal of normally black which performs a black display when an electric field is not applied to said liquid crystal is used as said liquid crystal.

43. A liquid crystal display device being characterized in that each liquid-crystal-side pixel region of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal includes a first electrode and a second electrode which is formed as a lower layer with respect to said first electrode by way of an insulation film and generates an electric field having a component parallel to said transparent substrates between said second electrode and said first electrode,

said second electrode is formed of a transparent electrode formed on a region which is disposed around said first electrode and is not superposed on at least said first electrode, and

a thickness of said insulation film between said superposed first and second electrodes is set larger than a thickness of said insulation film at said region which is disposed on said second electrode and on which said first electrode is not superposed.

44. A liquid crystal display device being characterized

in that, on a liquid-crystal-side rectangular pixel region of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed, and an electric field containing a component parallel to said transparent substrates is generated between said respective electrodes,

said one electrode out of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around said other electrode and is not superposed on said other electrode, and

said other electrode is constituted of a plurality of electrodes which are arranged in parallel in the direction which intersects the extension direction of said other electrode at a right angle, said electrodes including bent portions which change said extending direction, and electrodes which are extended linearly at least at portions of a periphery of said pixel region.

45. A liquid crystal display device according to claim 44, said other electrodes which are extended linearly at least portions of said periphery of said pixel region are connected with said other electrodes having bent portions which change said extending direction.

46. A liquid crystal display device according to claim

45, wherein said electrodes which are extended linearly at least at said portions of said periphery of said pixel region have a function of supplying video signals to said electrodes having said bent portions.

47. A liquid crystal display device according to claim 45 or 46, wherein said other electrodes which are extended linearly at said periphery of said pixel region is formed in a frame shape.

48. A liquid crystal display device being characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on a rectangular pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, and an electric field having a component parallel to said transparent substrates is generated between these electrodes,

one of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around said other electrode and is not superposed on said other electrode, and

said other electrode comprises a plurality of electrodes which are arranged in parallel in the direction perpendicular to an extension direction of said pixel electrode, wherein a plurality of electrodes consist of first electrodes having bent portions which change the extension direction and second

electrodes which run substantially at the center of said pixel region and are connected to said first electrodes.

49. A liquid crystal display device according to claim 48, wherein said first electrodes have said bent portions at a boundary portion which divides said pixel region in halves.

50. A liquid crystal display device being characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on a pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, and an electric field having a component parallel to said transparent substrates is generated between these electrodes,

one of said pixel electrode and said counter electrode is constituted of a transparent electrode which is formed on a region disposed around said other electrode and is not superposed on said other electrode, and

said other electrode comprises a plurality of electrodes which are arranged in parallel in the direction perpendicular to an extension direction of said pixel electrode and said respective electrodes are formed as bent patterns at a boundary portion of said pixel region which is divided in halves.

51. A liquid crystal display device according to claim 50, wherein the division of said pixel region is made in the direction which approximately intersects the initial

orientation direction of said liquid crystal, and an opening angle of said bent portions of said other electrodes having bent portions are set to an obtuse angle.

52. A liquid crystal display device being characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on each pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, and an electric field having a component parallel to said transparent substrates is generated between these electrodes,

one of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around said other electrode and is not superposed on said other electrode, and

said other electrode includes bent portions which change the extension direction and light-shielding members are formed on said bent portions by way of an insulation film.

53. A liquid crystal display device according to claim 52, wherein said other electrode is constituted of a plurality of electrodes which are arranged in parallel in the direction which intersects the extension direction of said other electrode, bent portions of said respective electrodes are positioned on an imaginary line which transverses substantially the center of said pixel region, and a light-shielding member

is formed on and along said imaginary line.

54. A liquid crystal display device according to claim 53, wherein said light shielding member is formed as a portion of a counter voltage signal line which applies counter voltage signals to said counter electrode.

55. A liquid crystal display device being characterized in that a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on a pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, and an electric field having a component parallel to said transparent substrates is generated between these electrodes,

one of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around said other electrode and is not superposed on said other electrode, and

said other electrode includes a bent portion which changes the extension direction and an opening angle of said electrode with respect to said bent portion assumes an acute angle.

Abstract

In a liquid crystal display device which drives a liquid crystal layer in a lateral electric field system, an image display function is performed. To achieve this end, according to the present invention, a pixel electrode and a counter electrode which are arranged by way of an insulation film are formed on each pixel region at a liquid-crystal side of one transparent substrate out of transparent substrates which are arranged to face each other in an opposed manner by way of liquid crystal, an electric field having a component parallel to said transparent substrates is generated between these respective electrodes, one electrode out of said pixel electrode and said counter electrode is constituted of a transparent electrode formed on a region which is disposed around the other electrode and is not superposed on the other electrode, and an insulation film has a multi-layered structure.

FIG. 1

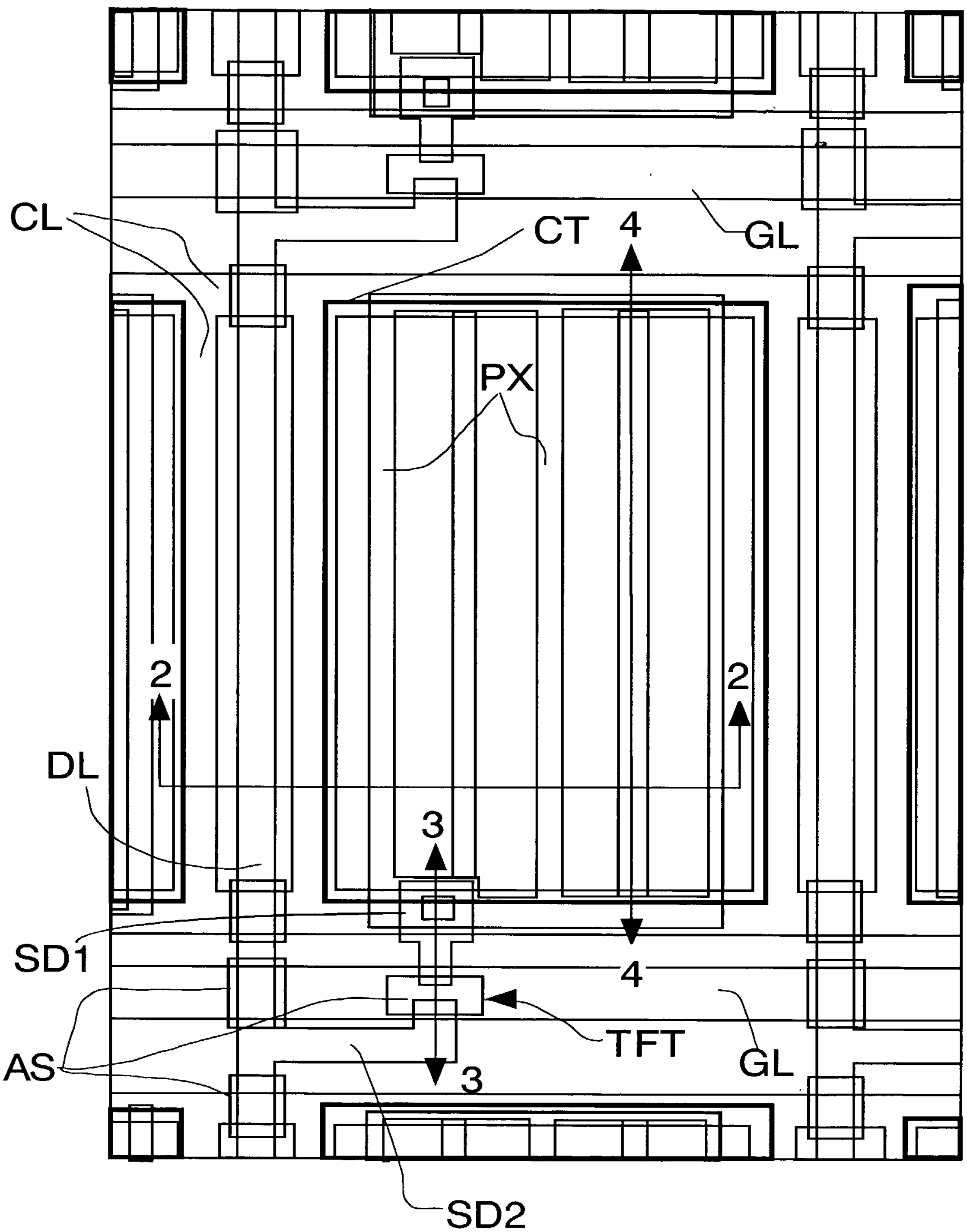
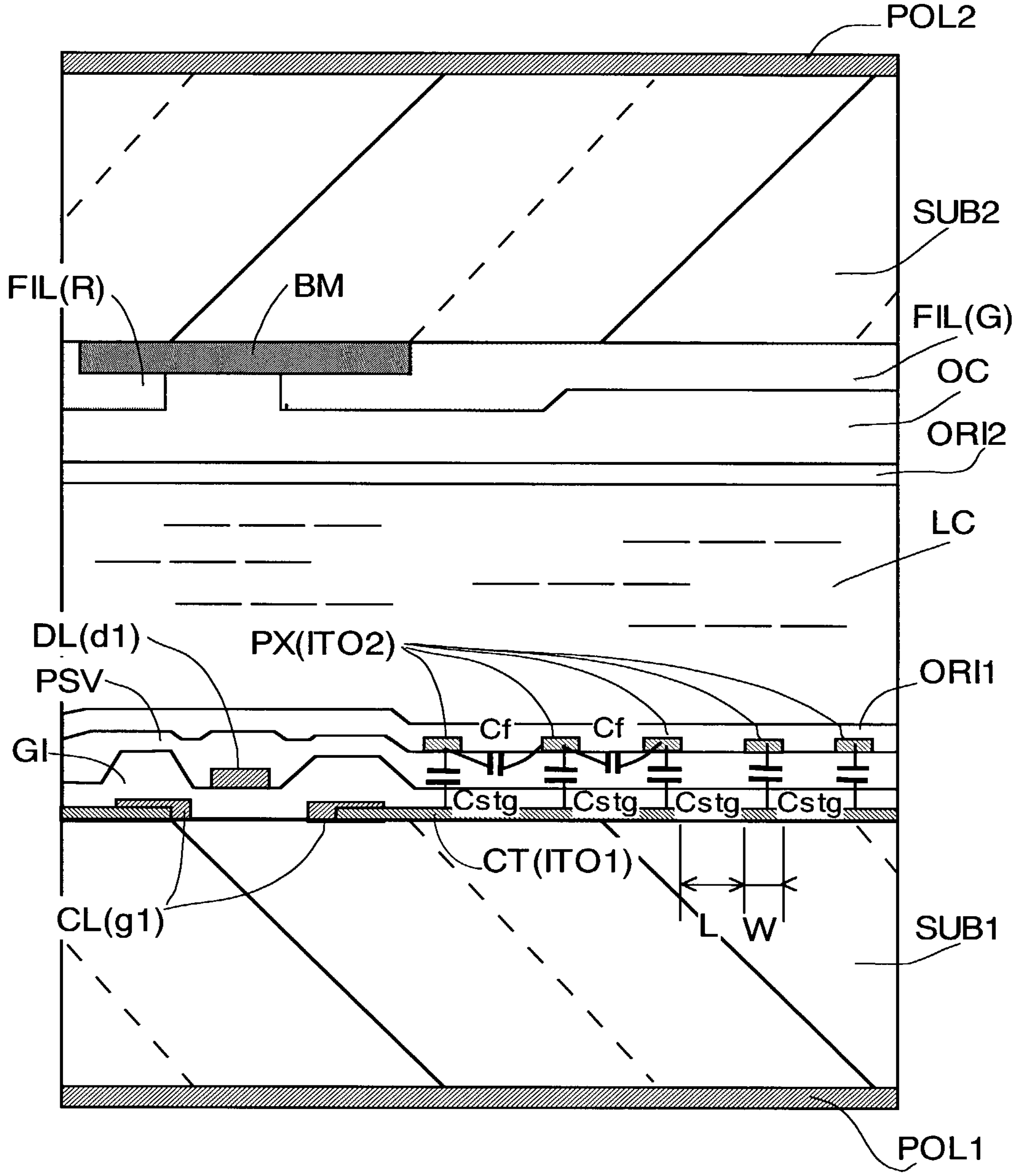


FIG. 2



POL2
SUB2
FIL(R)
BM
FIL(G)
OC
ORI2
LC
DL(d1)
PX(ITO2)
ORI1
PSV
Cf
Cf
GI
Cstg
Cstg
Cstg
Cstg
CT(ITO1)
L
W
CL(g1)
SUB1
POL1

FIG. 3

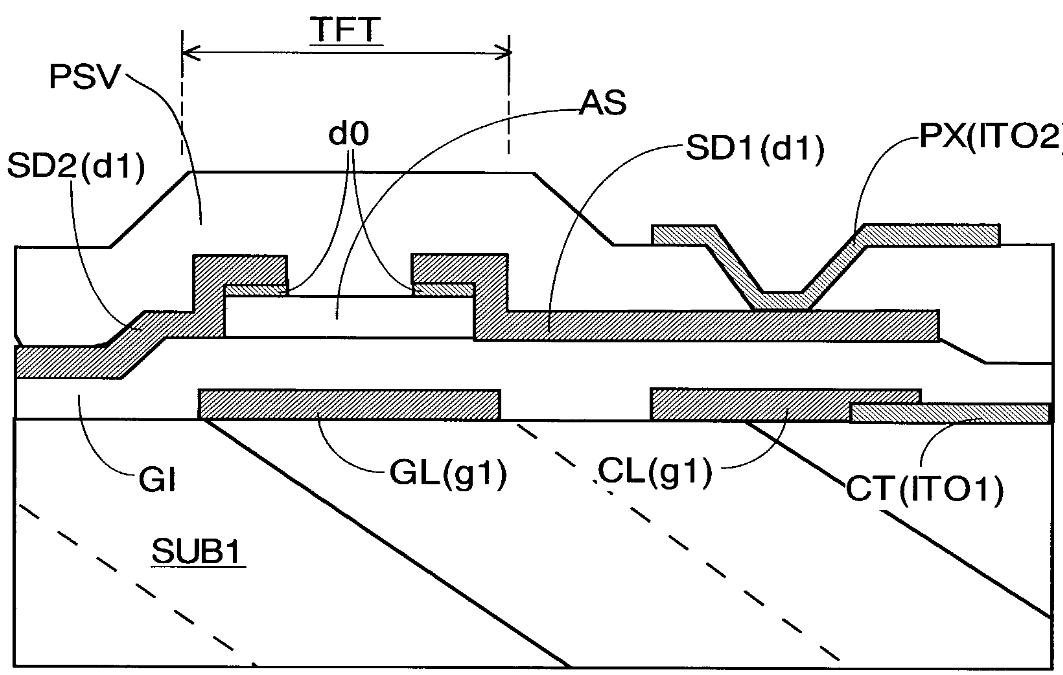


FIG. 4

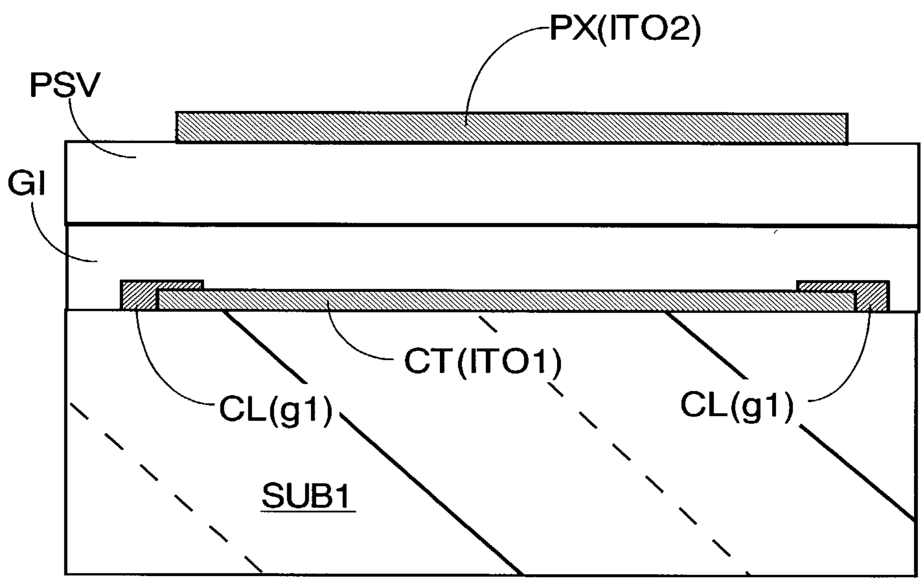


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FIG. 5

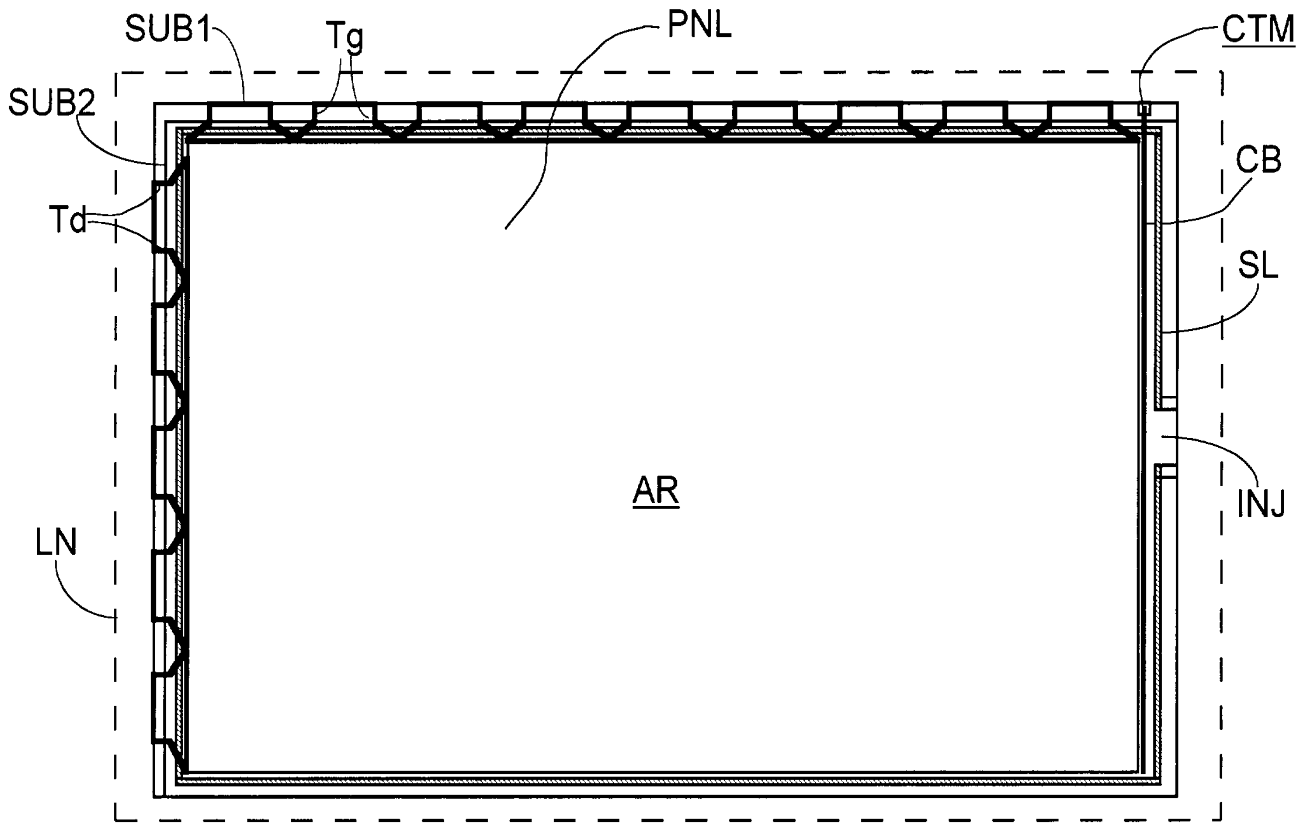
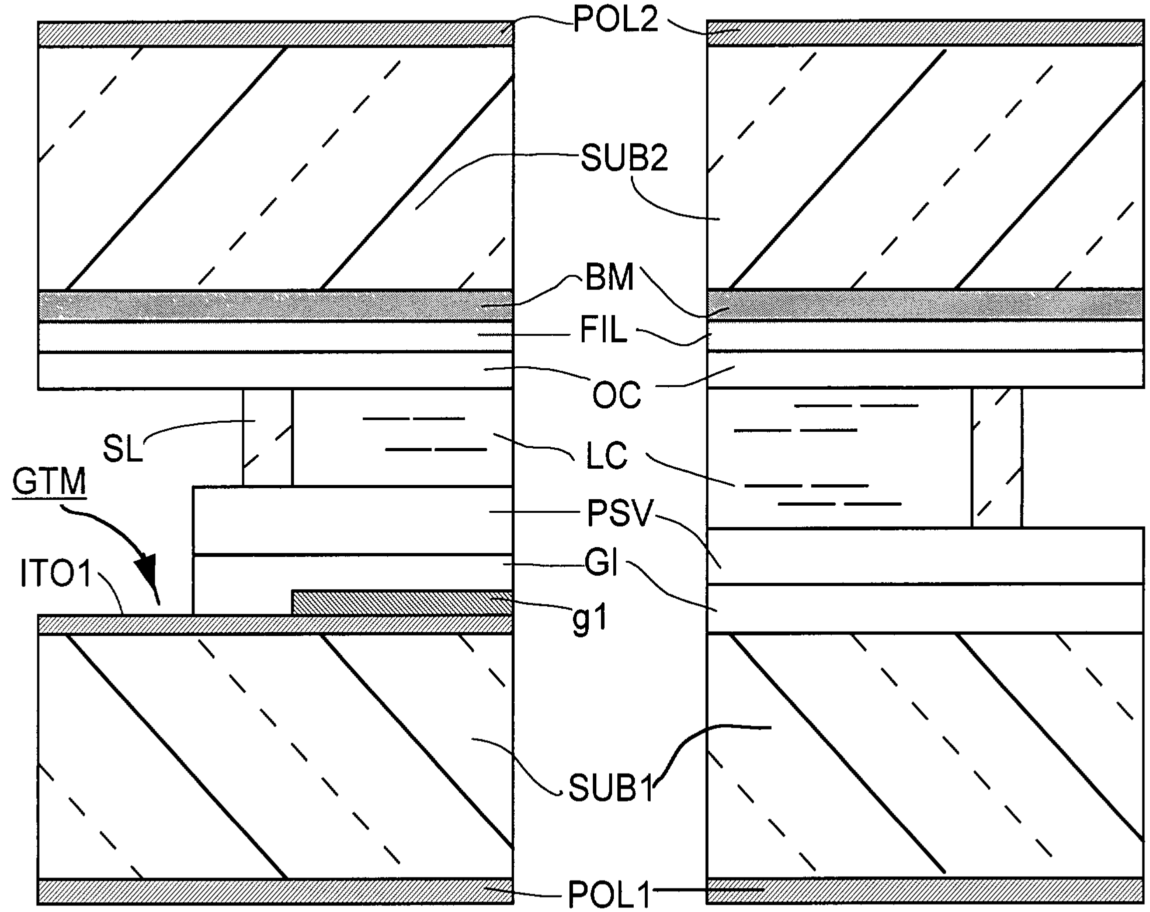


FIG. 6A

FIG. 6B



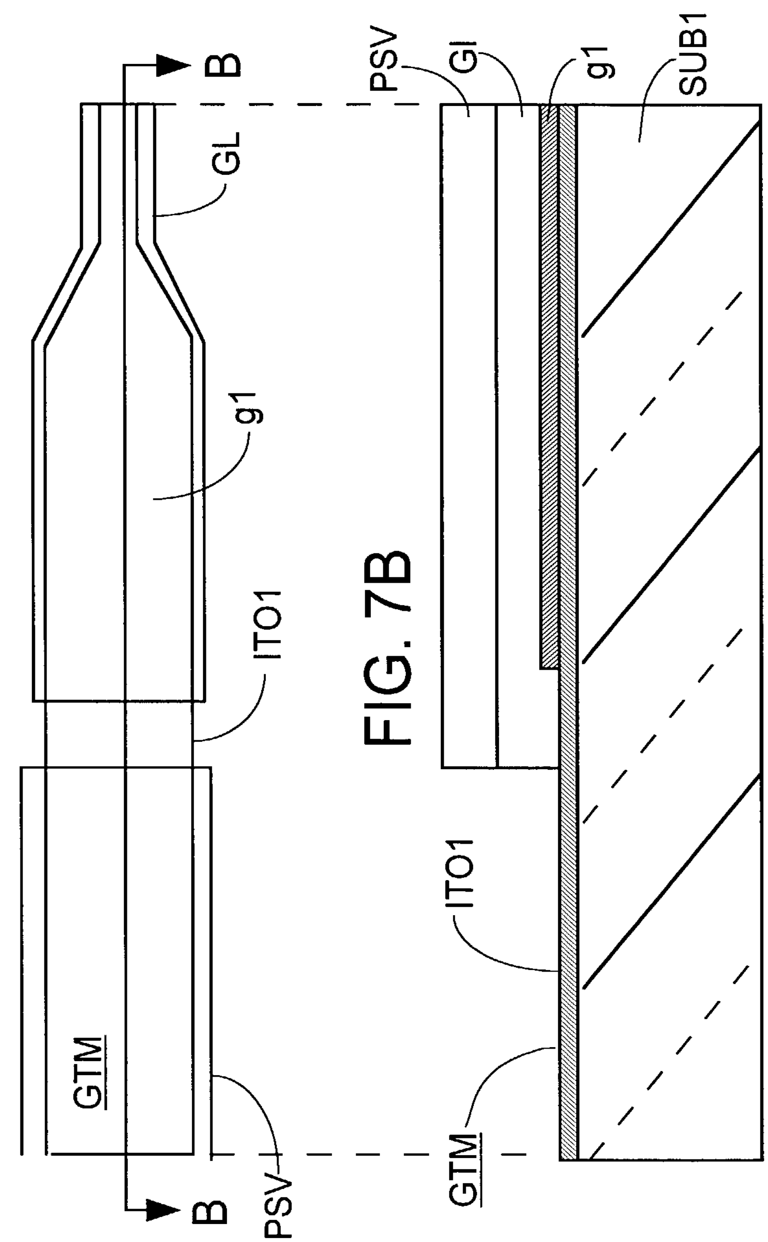


FIG. 7A

FIG. 7B

FIG. 8A

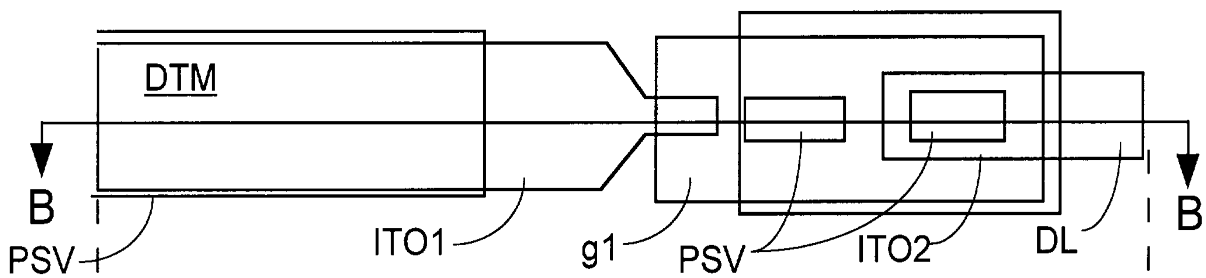


FIG. 8B

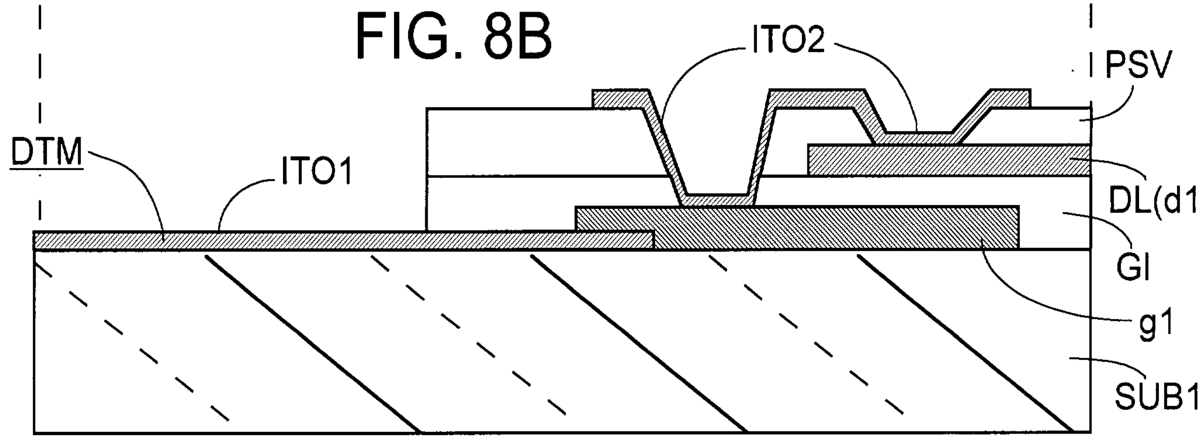


FIG. 9A

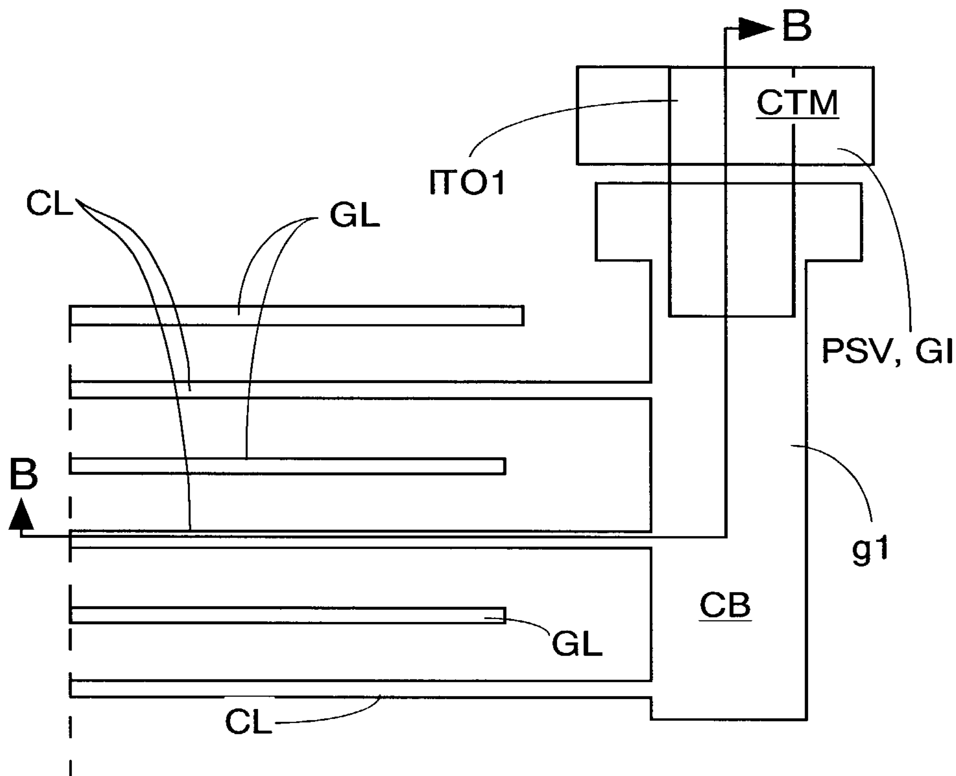


FIG. 9B

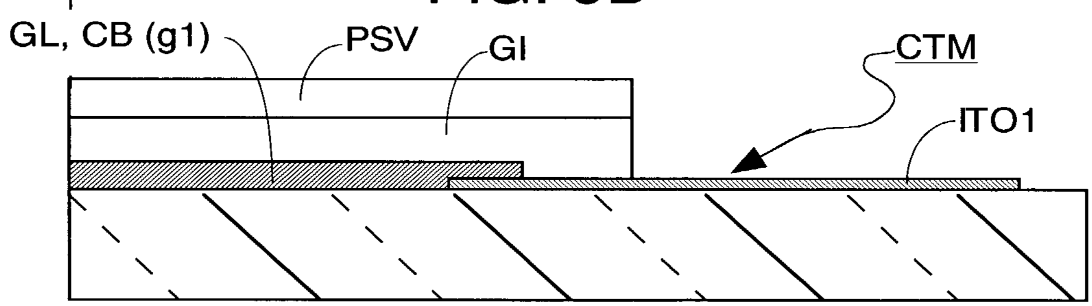


FIG. 10

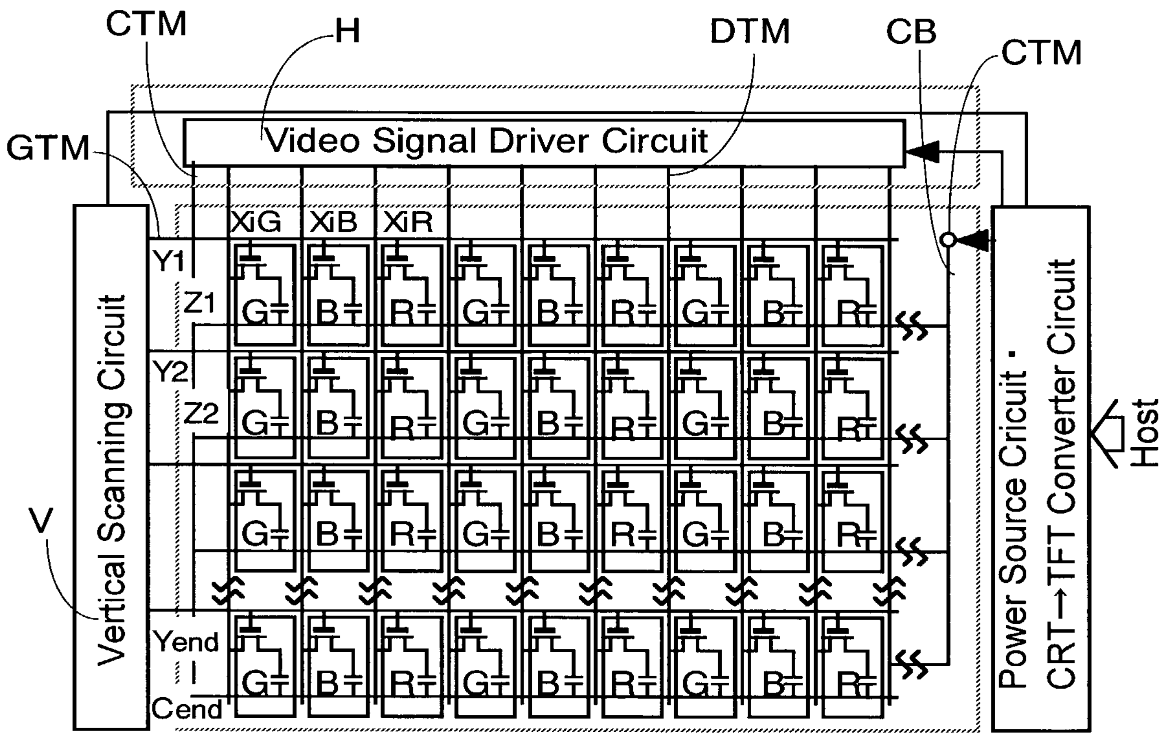

CTM
H
DTM
CB
CTM
GTM
Video Signal Driver Circuit
XiG
XiB
XiR
Y1
Z1
Y2
Z2
V
Vertical Scanning Circuit
Yend
Cend
Power Source Cricuit ·
CRT→TFT Converter Circuit
Host

FIG. 11

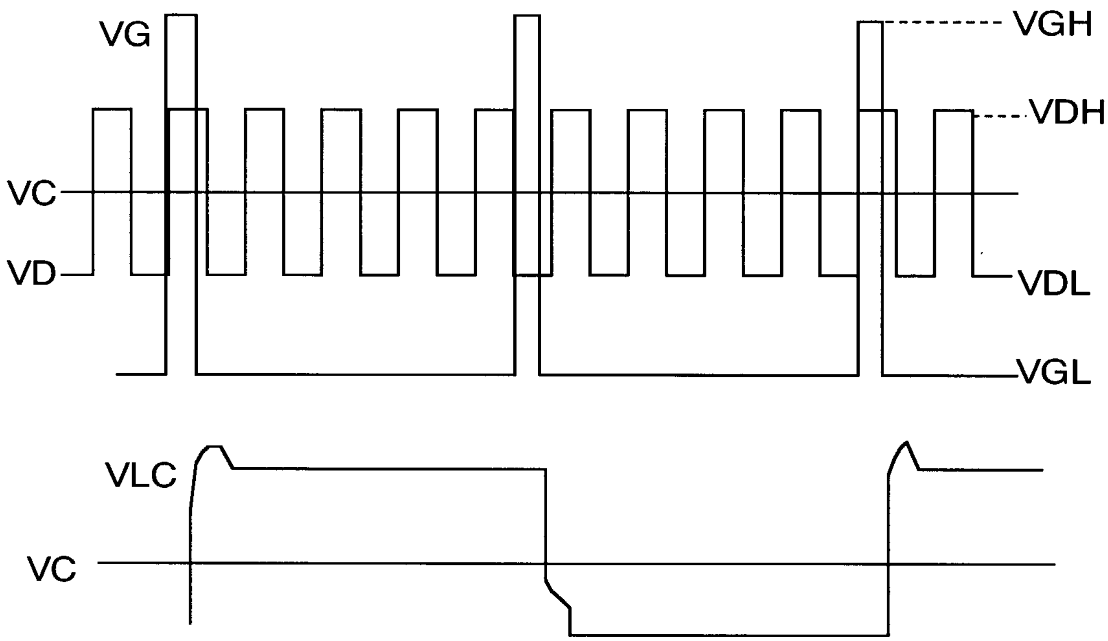


FIG. 12

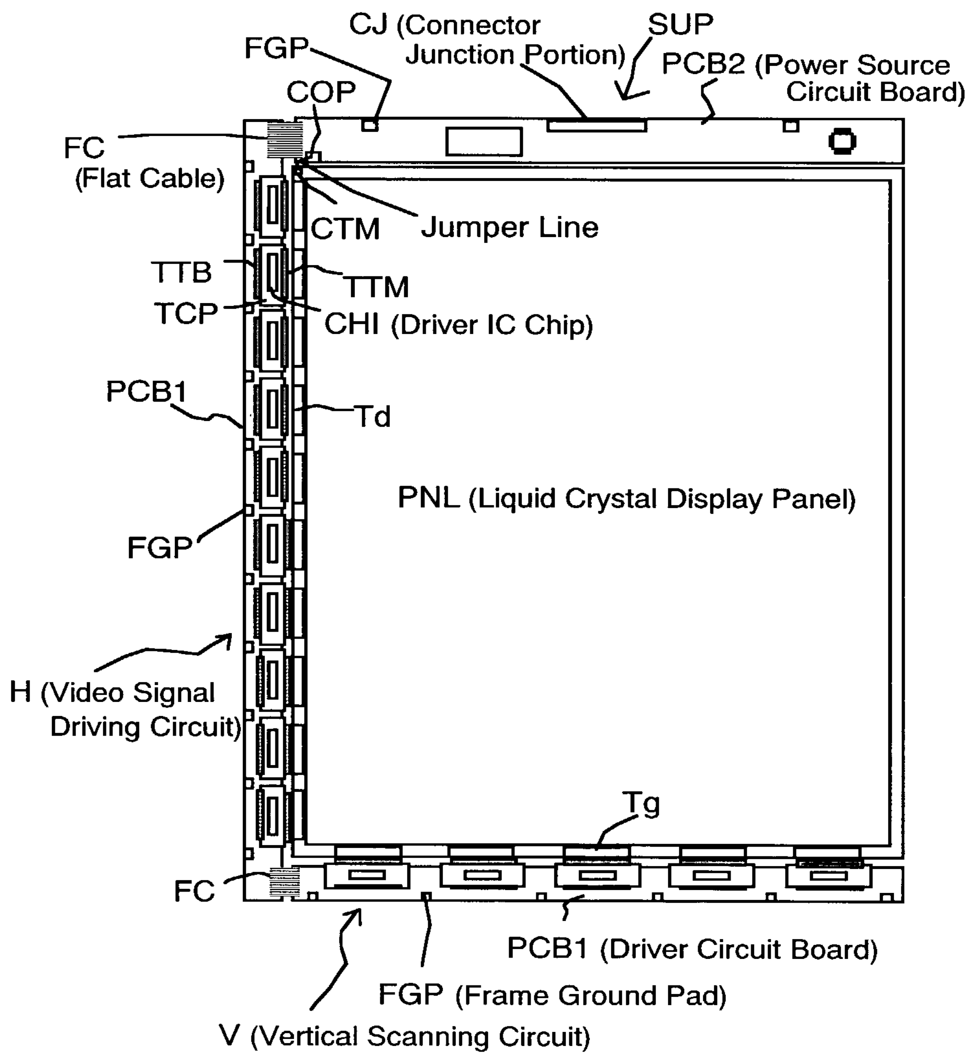
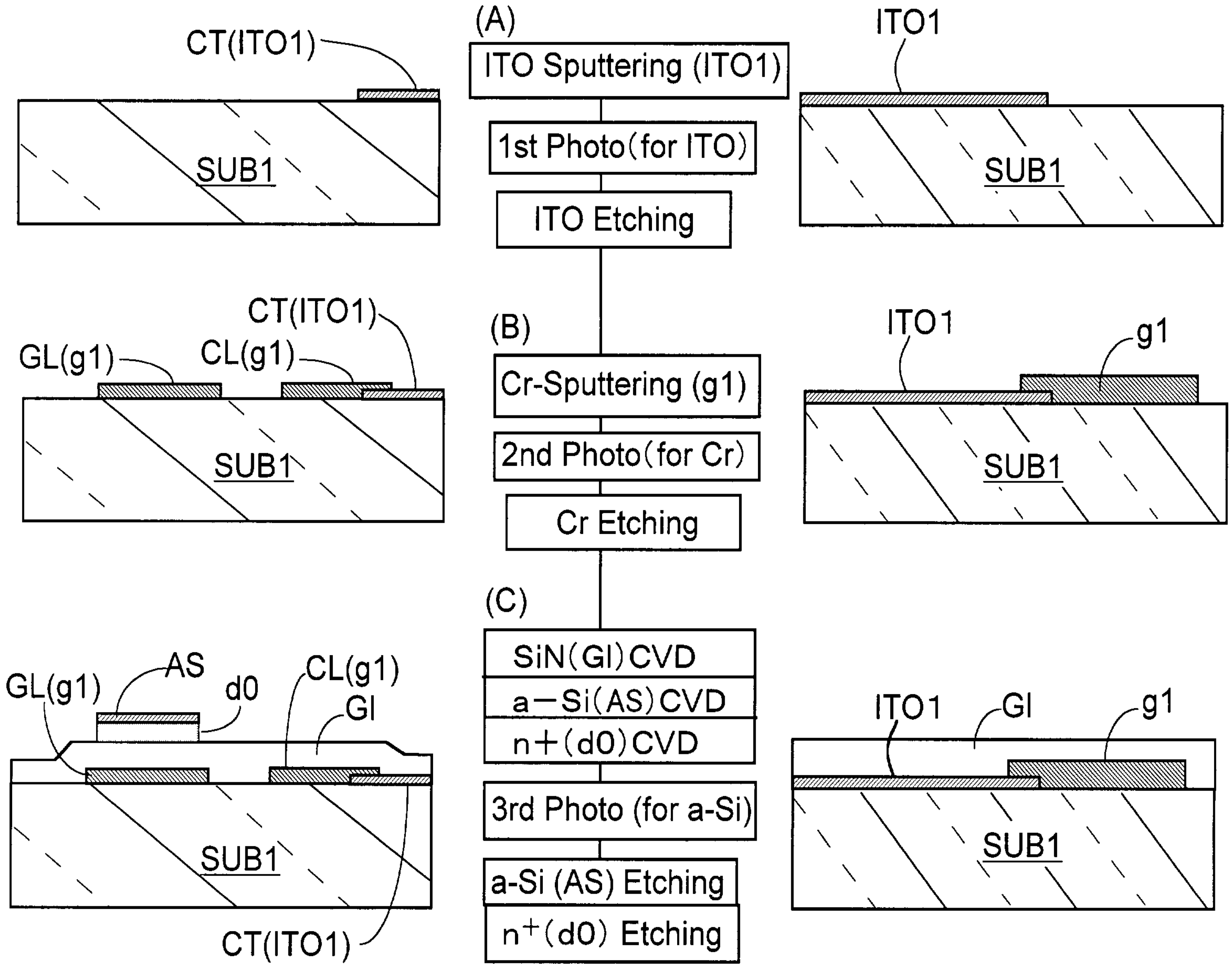

CJ (Connector
Junction Portion)
SUP
FGP
PCB2 (Power Source
Circuit Board)
COP
FC
(Flat Cable)
CTM
Jumper Line
TTB
TTM
TCP
CHI (Driver IC Chip)
PCB1
Td
PNL (Liquid Crystal Display Panel)
FGP
H (Video Signal
Driving Circuit)
Tg
FC
PCB1 (Driver Circuit Board)
FGP (Frame Ground Pad)
V (Vertical Scanning Circuit)

FIG. 13


(A)
ITO Sputtering (ITO1)
1st Photo (for ITO)
ITO Etching
(B)
Cr-Sputtering (g1)
2nd Photo (for Cr)
Cr Etching
(C)
SiN(GI)CVD
a−Si(AS)CVD
n+(d0)CVD
3rd Photo (for a-Si)
a-Si (AS) Etching
n+(d0) Etching
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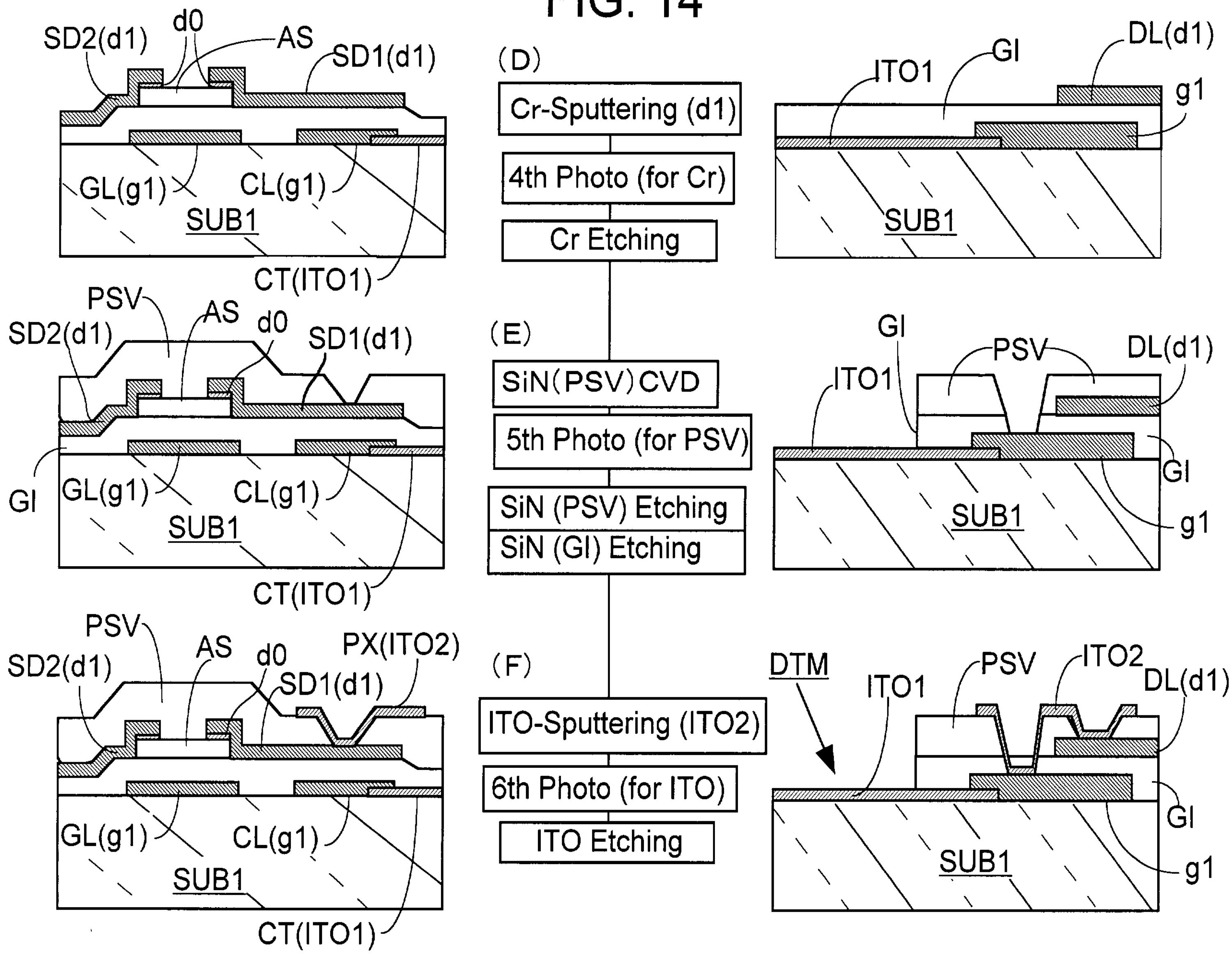
g1
GI
SUB1
CT(ITO1)
GL(g1)
CL(g1)
AS
d0

FIG. 14



10/070538

FIG. 15

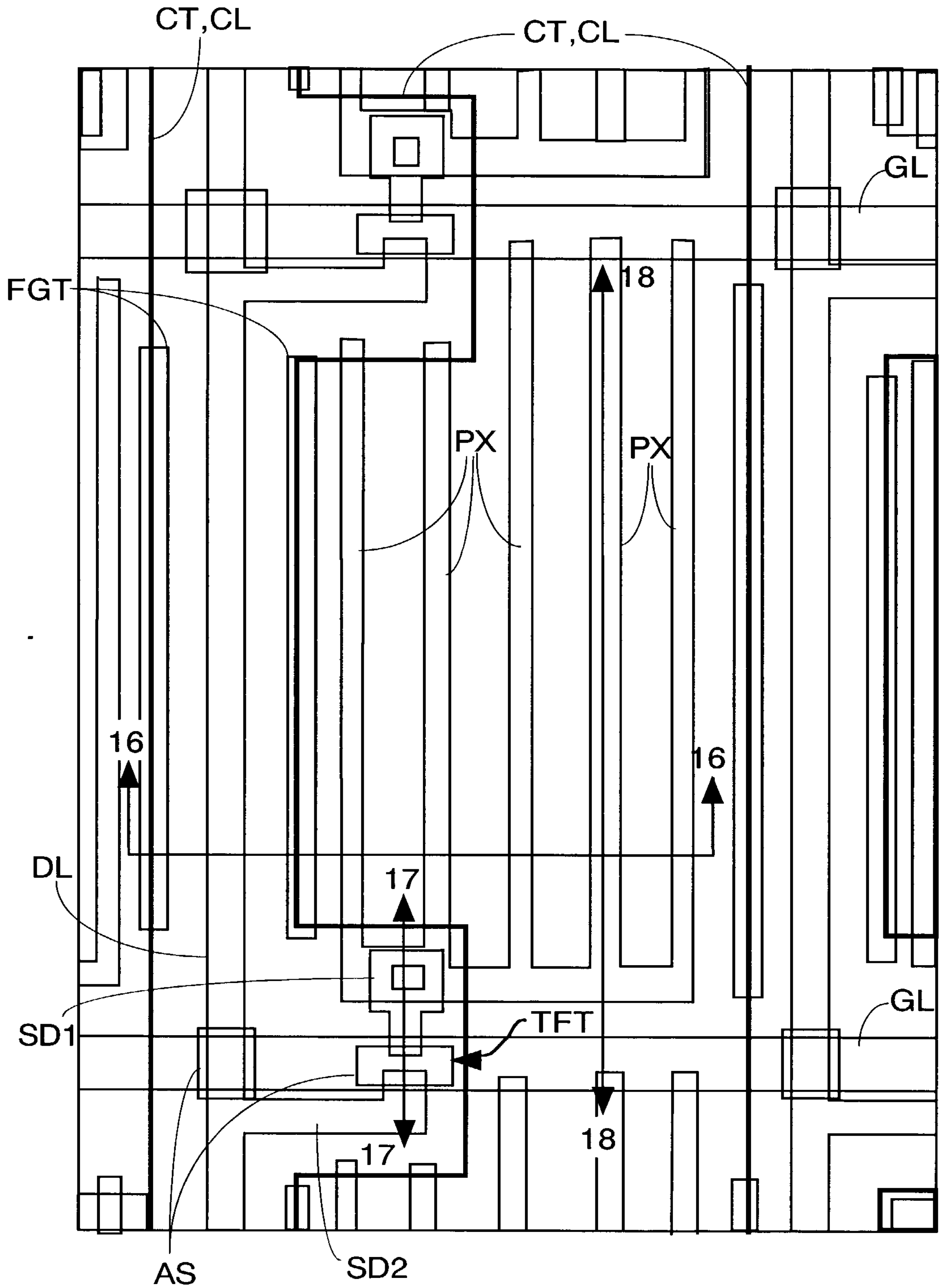
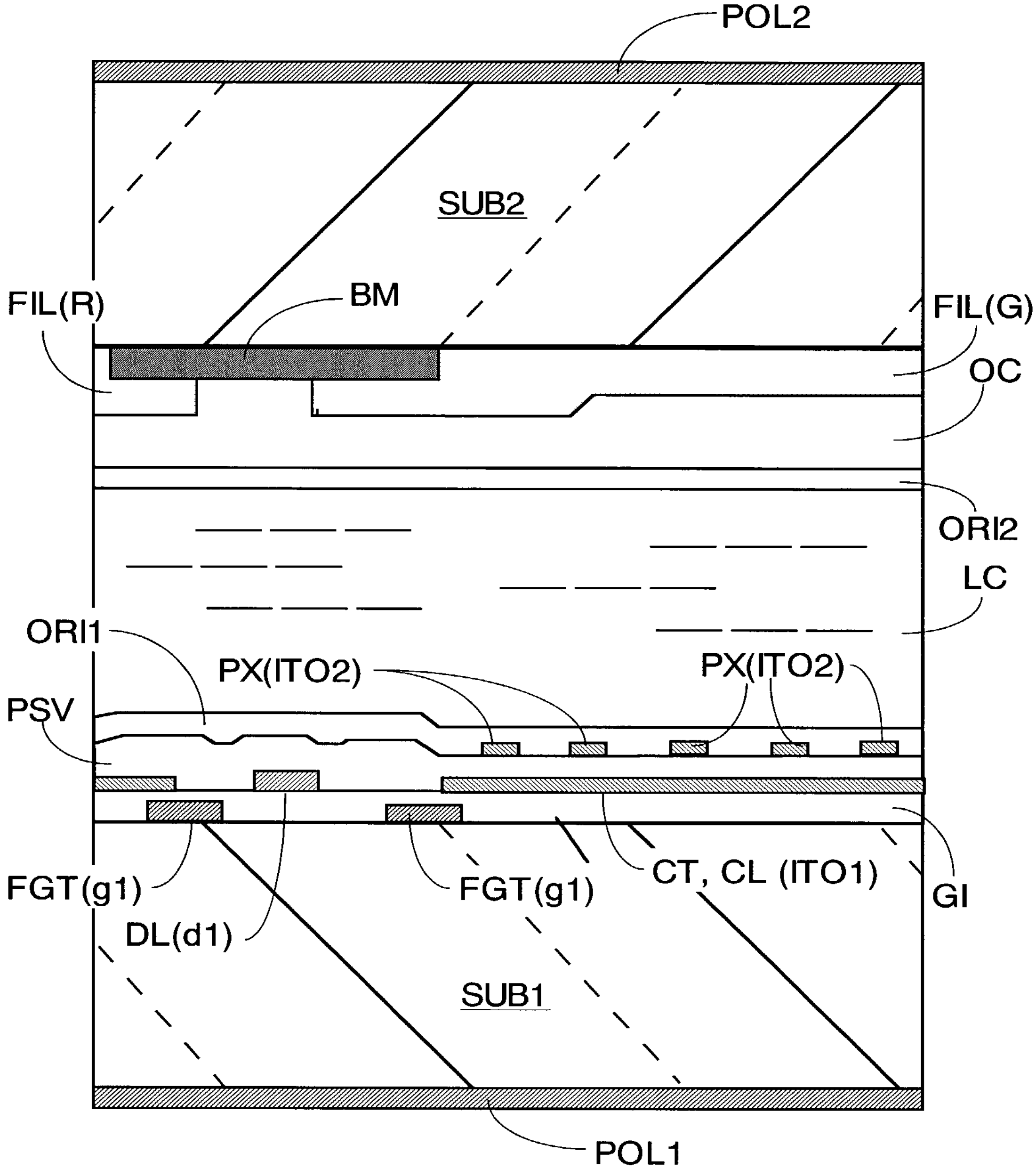


FIG. 16


POL2
SUB2
FIL(R)
BM
FIL(G)
OC
ORI2
LC
ORI1
PX(ITO2)
PX(ITO2)
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FGT(g1)
FGT(g1)
CT, CL (ITO1)
GI
DL(d1)
SUB1
POL1

FIG. 17

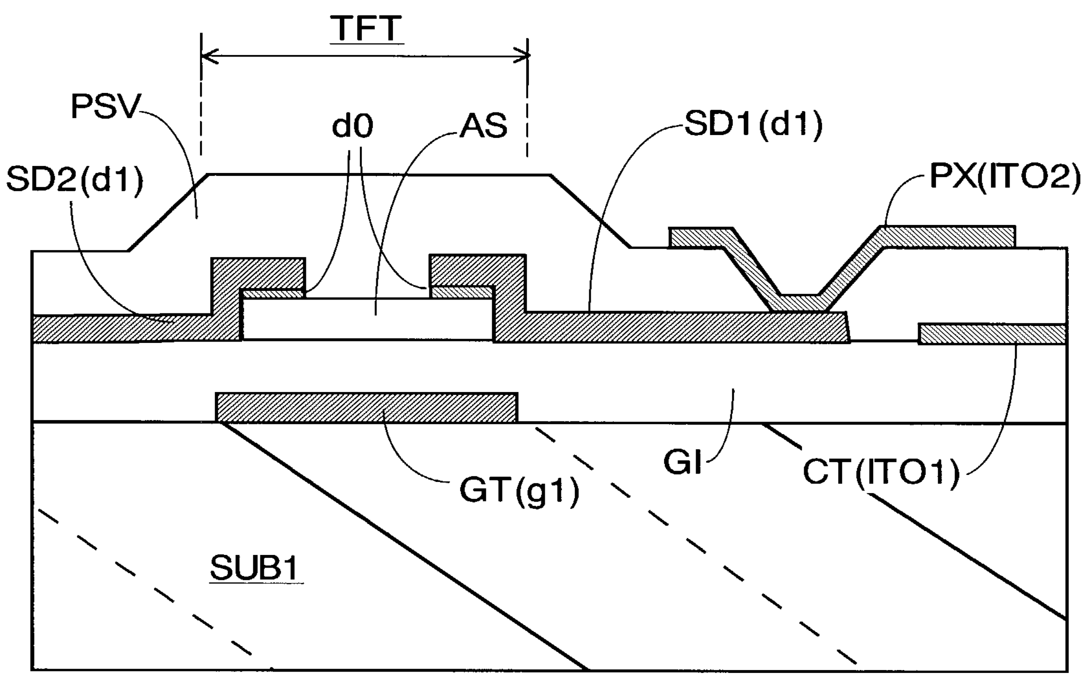


FIG. 18

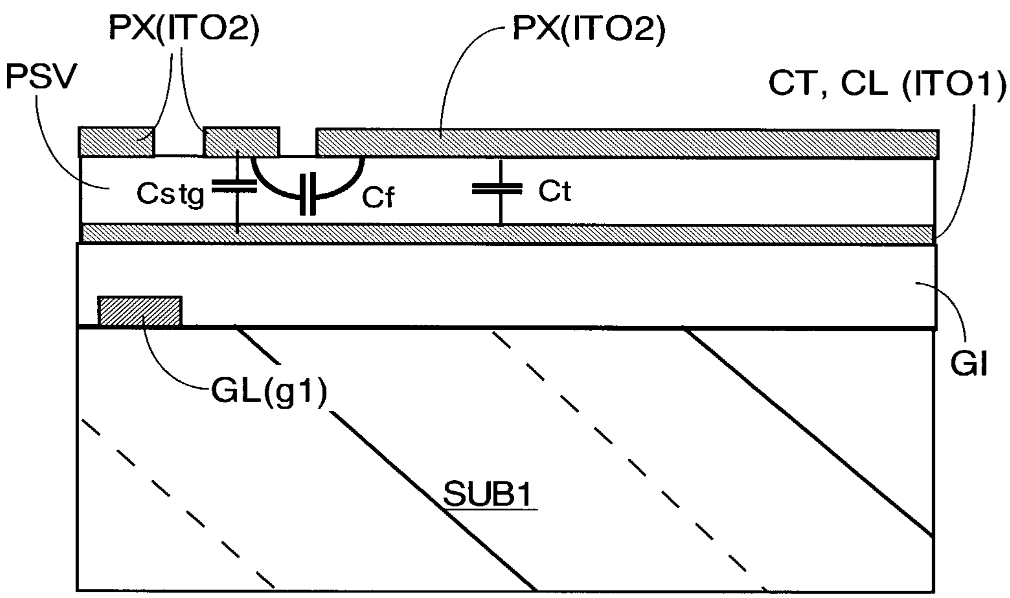
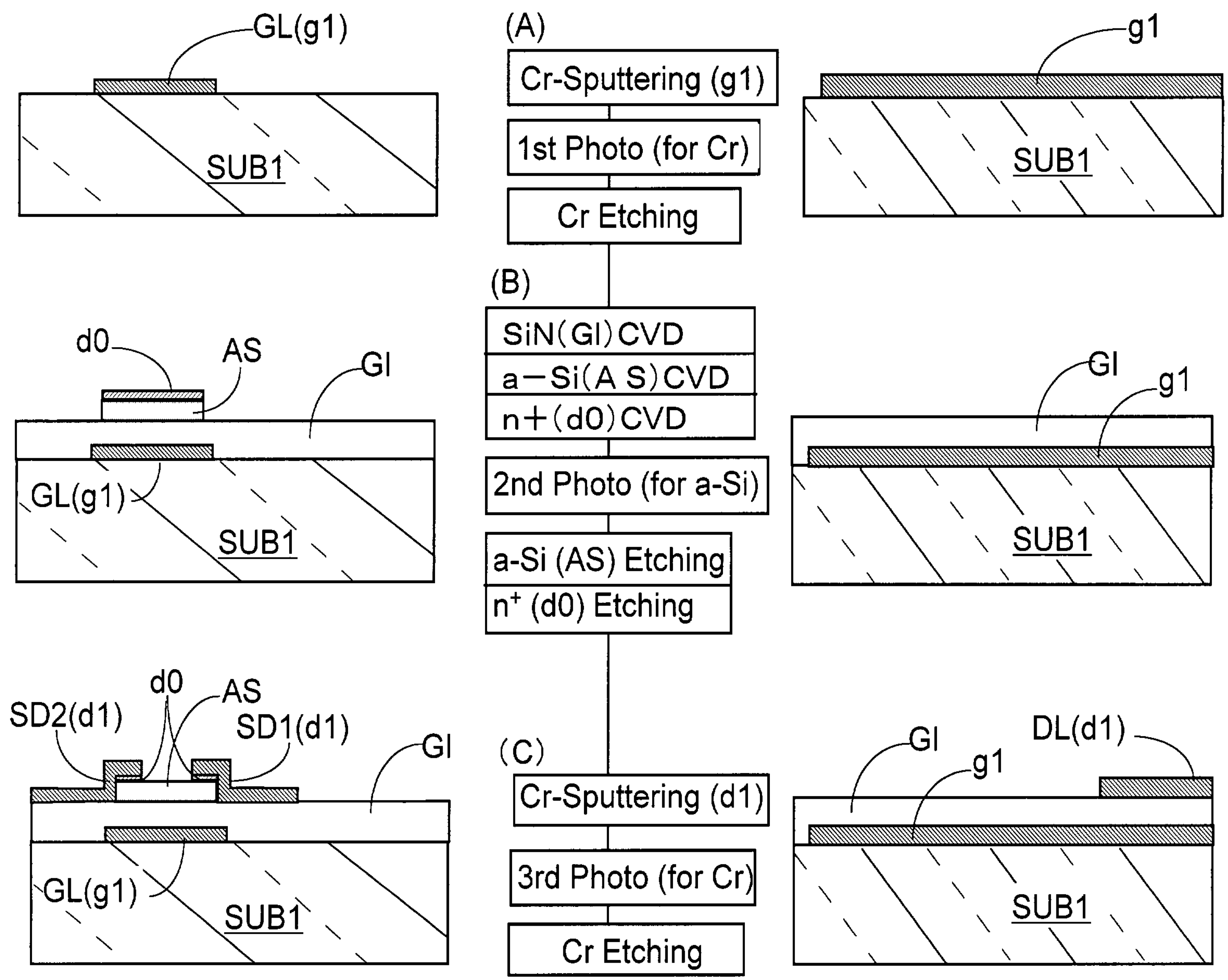


FIG. 19



GL(g1)
SUB1
(A)
Cr-Sputtering (g1)
1st Photo (for Cr)
Cr Etching
g1
SUB1
d0
AS
GI
GL(g1)
SUB1
(B)
SiN(GI)CVD
a−Si(A S)CVD
n+(d0)CVD
2nd Photo (for a-Si)
a-Si (AS) Etching
n+ (d0) Etching
GI
g1
SUB1
SD2(d1)
d0
AS
SD1(d1)
GI
GL(g1)
SUB1
(C)
Cr-Sputtering (d1)
3rd Photo (for Cr)
Cr Etching
GI
g1
DL(d1)
SUB1

10/070538

FIG. 20

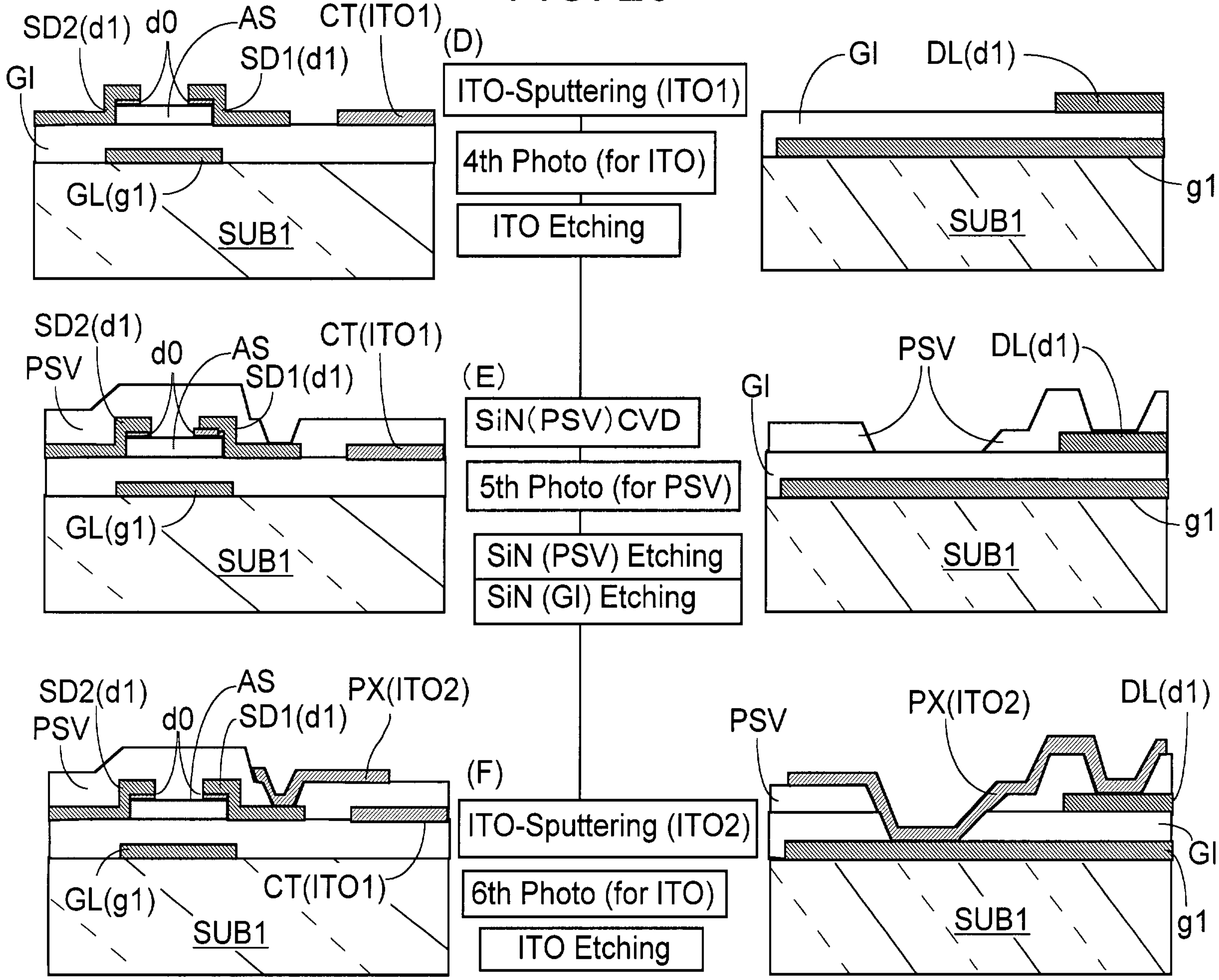


FIG. 21

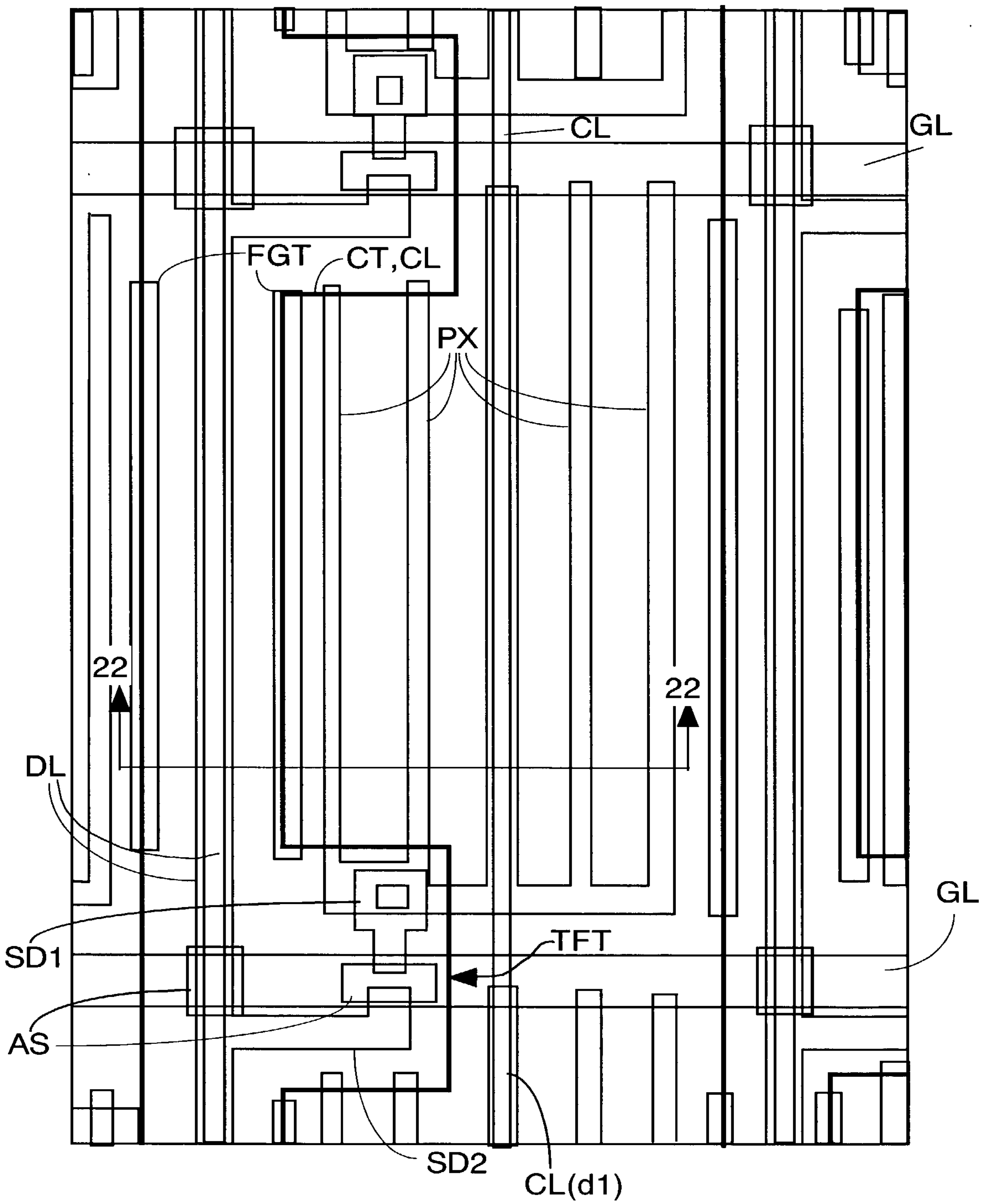


FIG. 22

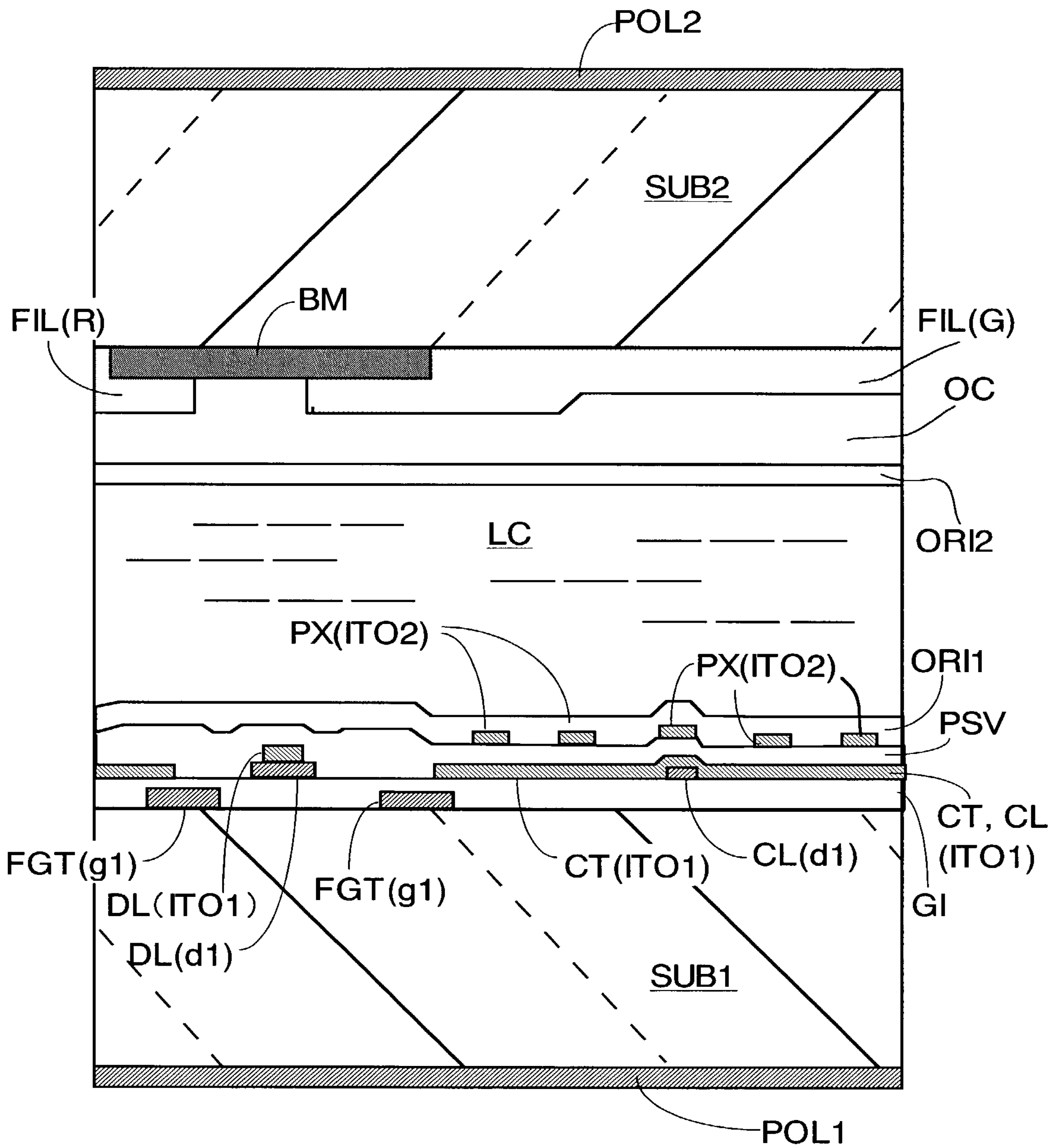

POL2
SUB2
FIL(R)
BM
FIL(G)
OC
ORI2
LC
PX(ITO2)
PX(ITO2)
ORI1
PSV
CT, CL
(ITO1)
FGT(g1)
DL(ITO1)
DL(d1)
FGT(g1)
CT(ITO1)
CL(d1)
GI
SUB1
POL1

FIG. 23

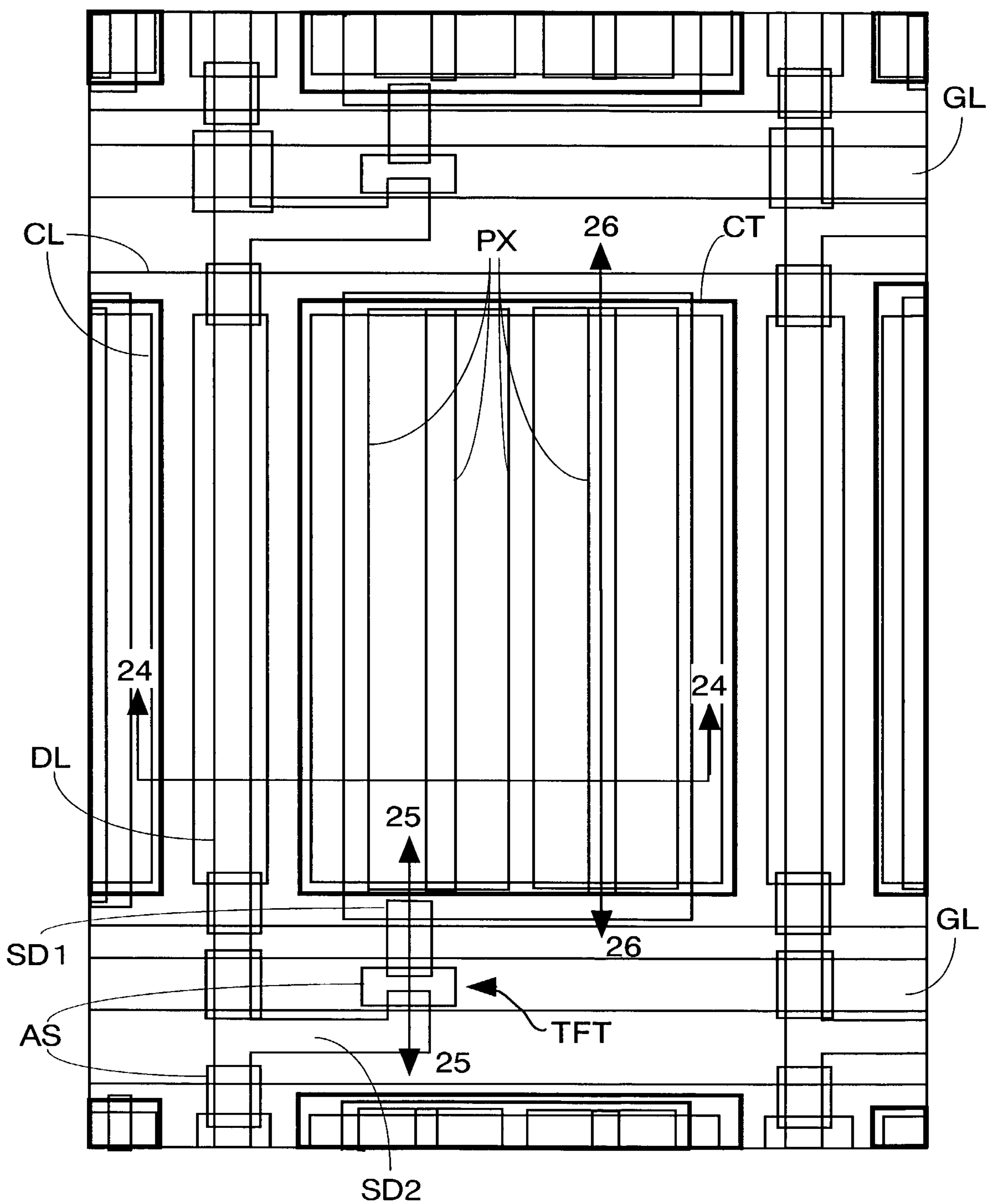


FIG. 24

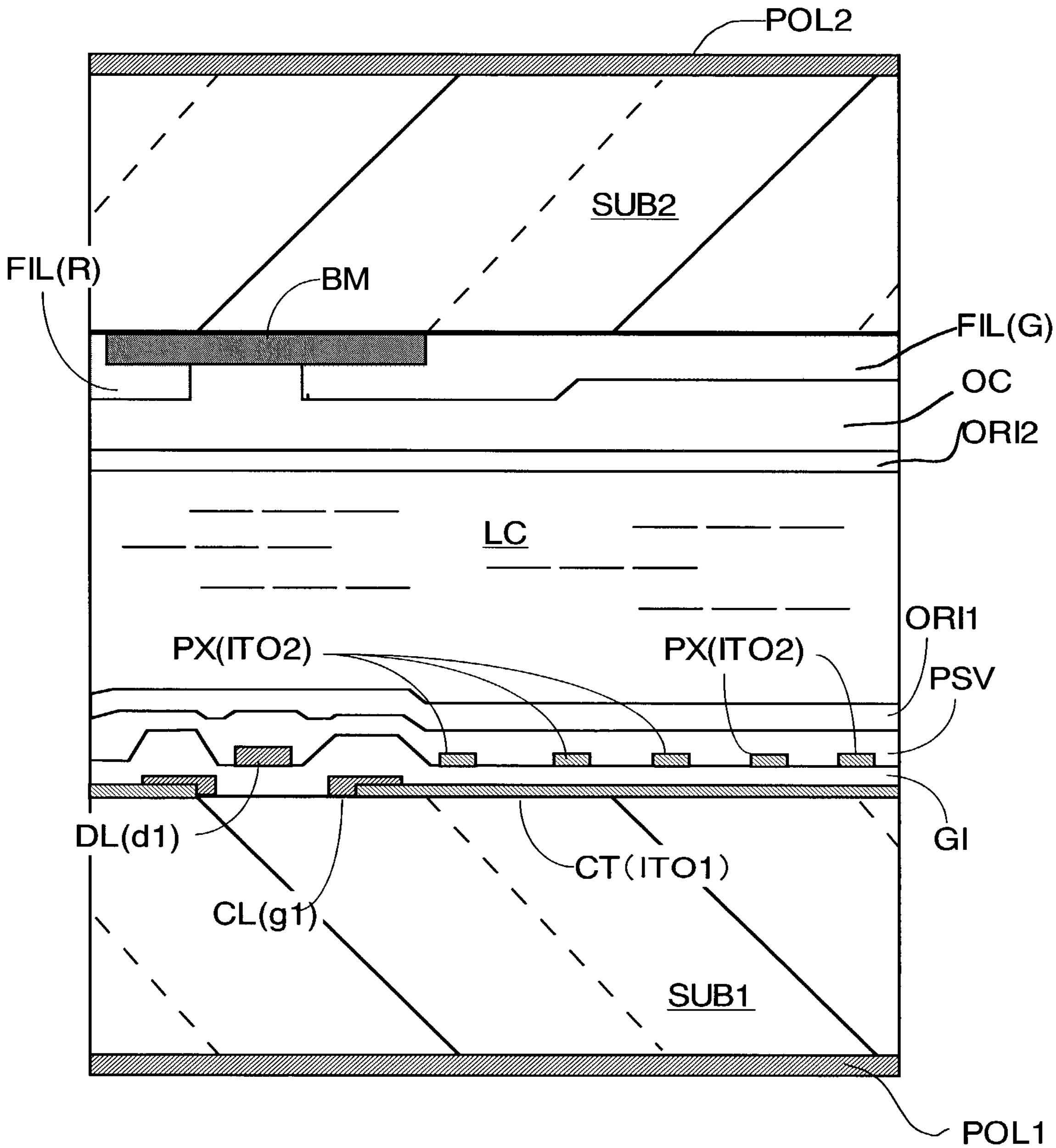

POL2
SUB2
FIL(R)
BM
FIL(G)
OC
ORI2
LC
ORI1
PX(ITO2)
PX(ITO2)
PSV
GI
DL(d1)
CT(ITO1)
CL(g1)
SUB1
POL1

FIG. 25

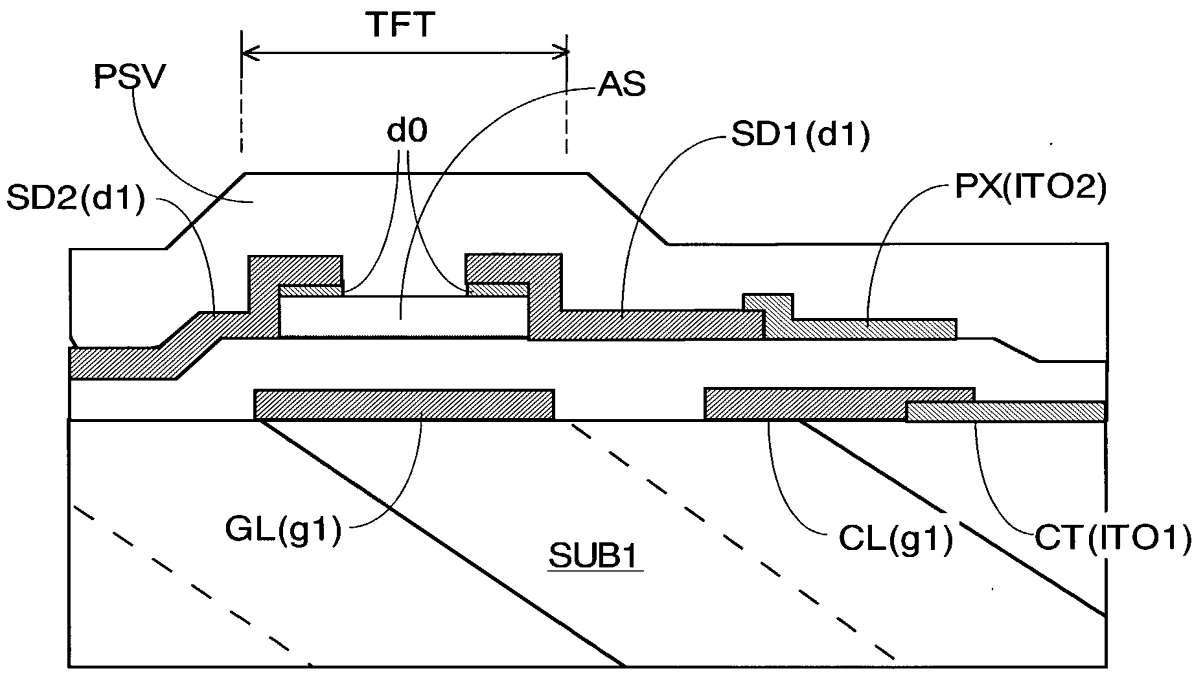


FIG. 26

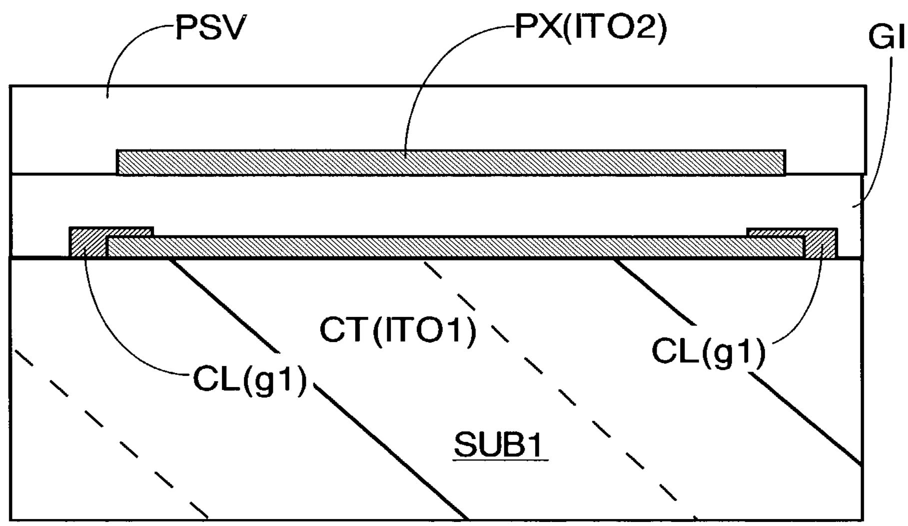


FIG. 27

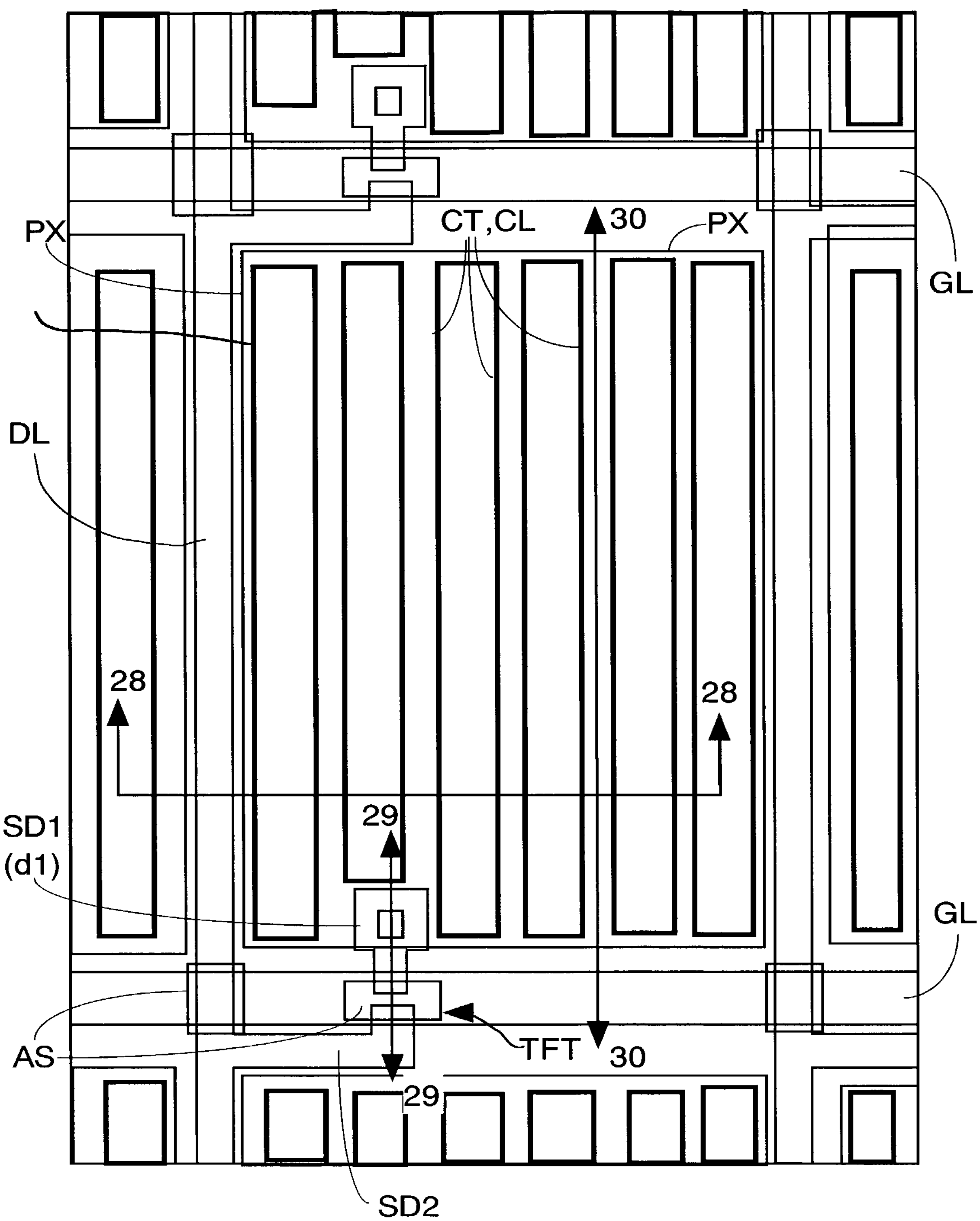


FIG. 28

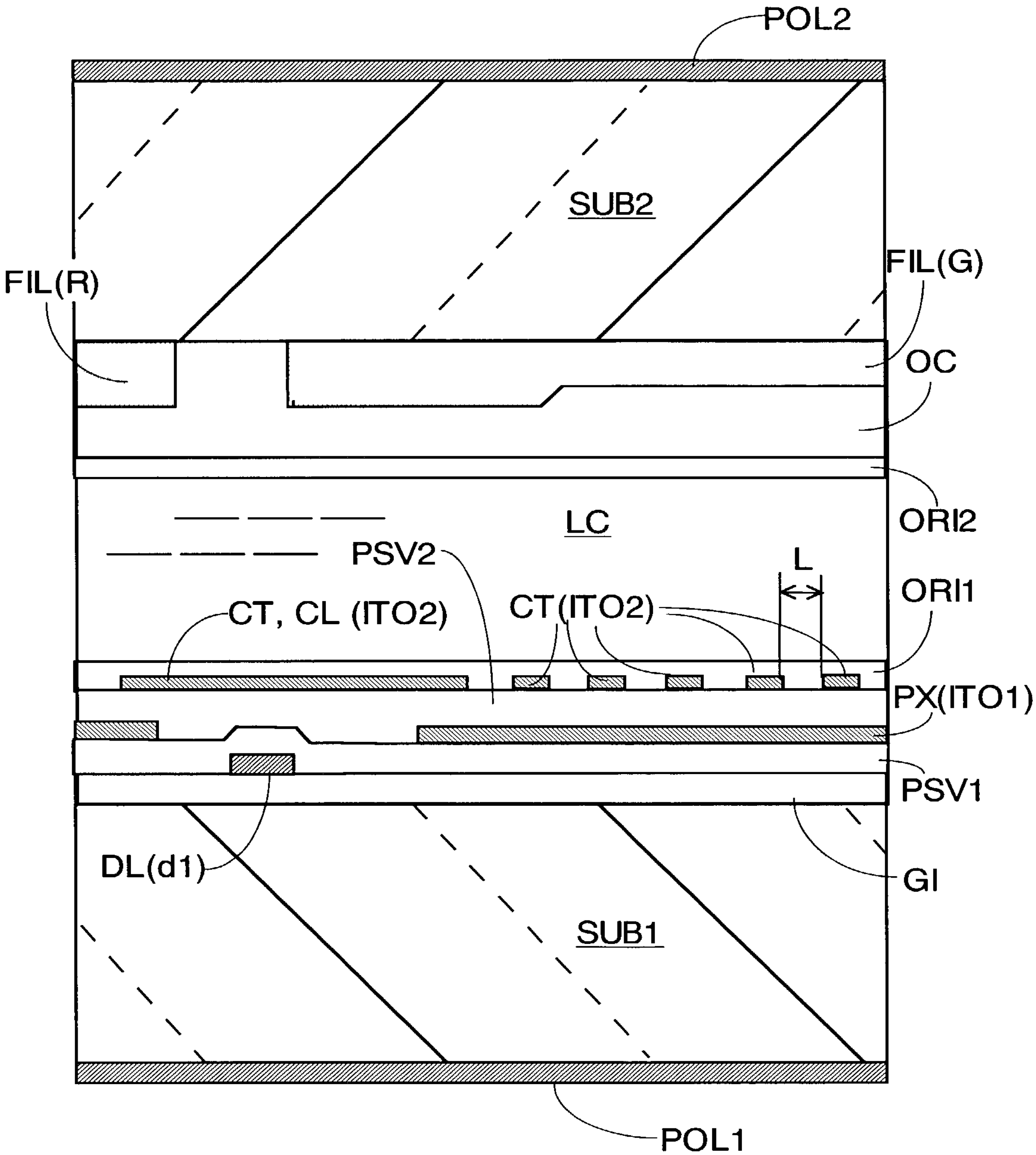

POL2
SUB2
FIL(R)
FIL(G)
OC
LC
ORI2
PSV2
L
ORI1
CT, CL (ITO2)
CT(ITO2)
PX(ITO1)
PSV1
DL(d1)
GI
SUB1
POL1

FIG. 29

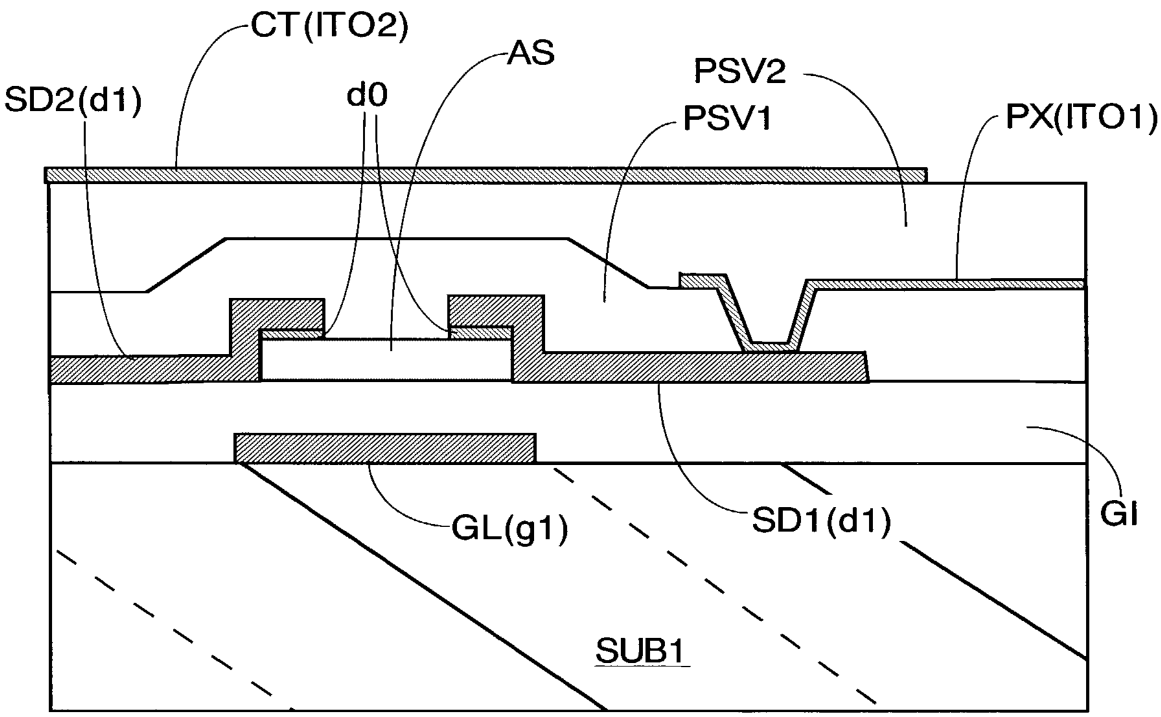


FIG. 30

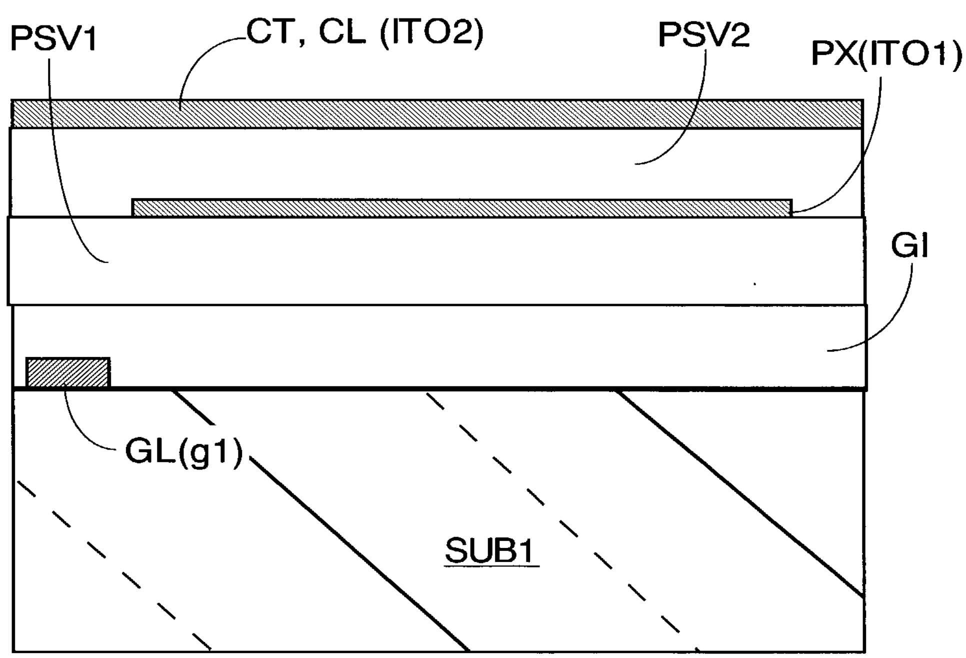


FIG. 31

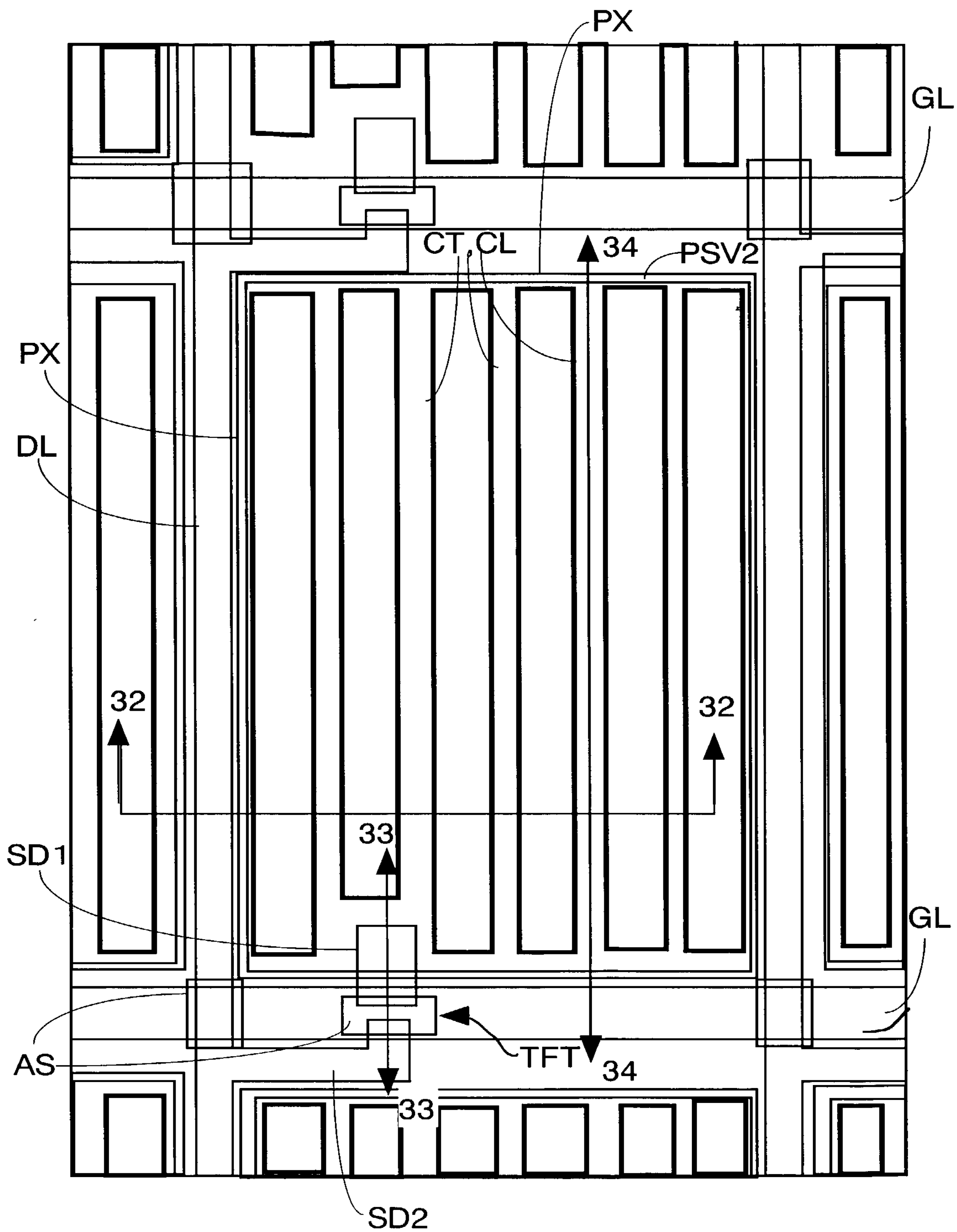


FIG. 32

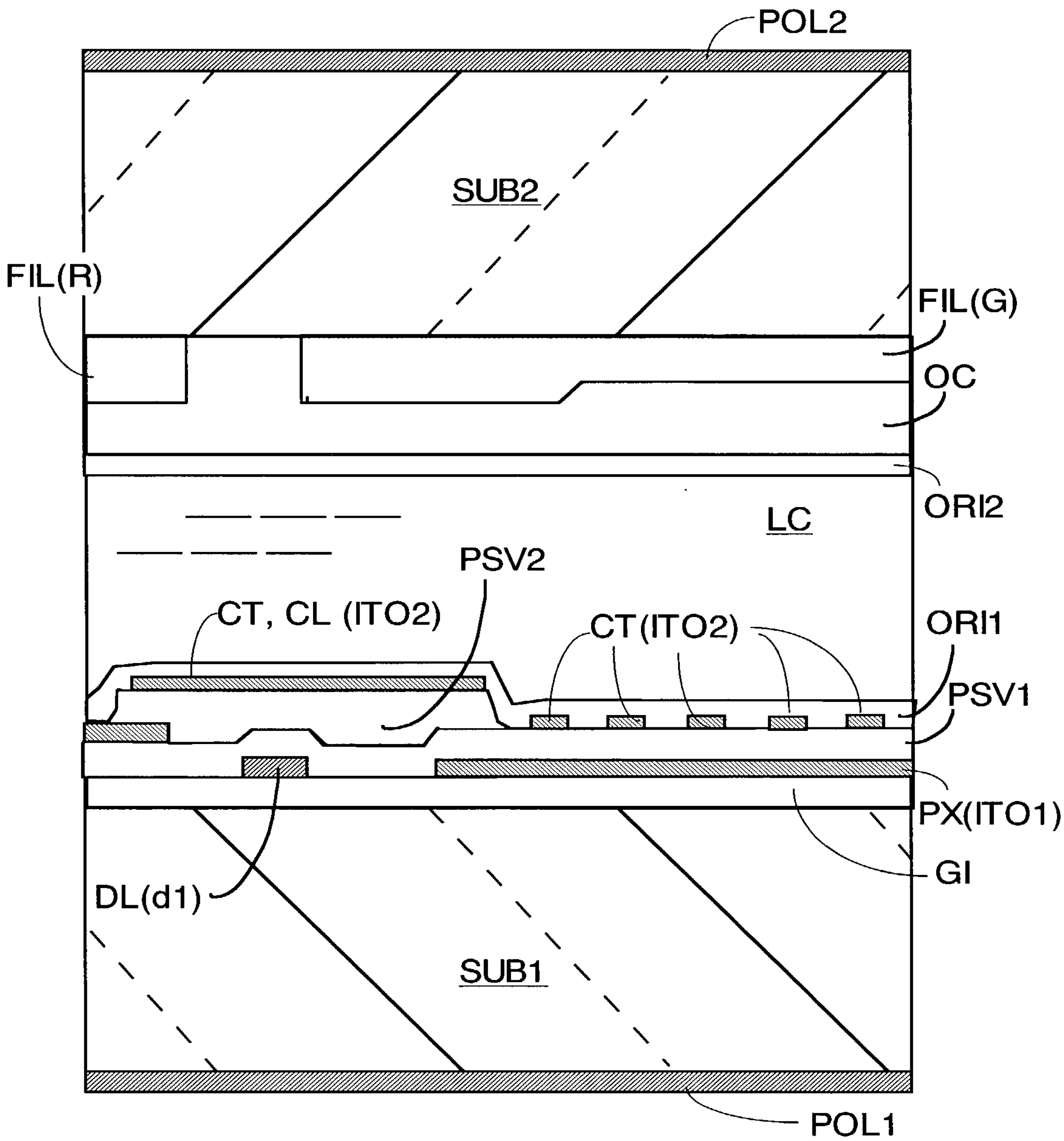

POL2
SUB2
FIL(R)
FIL(G)
OC
ORI2
LC
PSV2
CT, CL (ITO2)
CT(ITO2)
ORI1
PSV1
PX(ITO1)
GI
DL(d1)
SUB1
POL1

FIG. 33

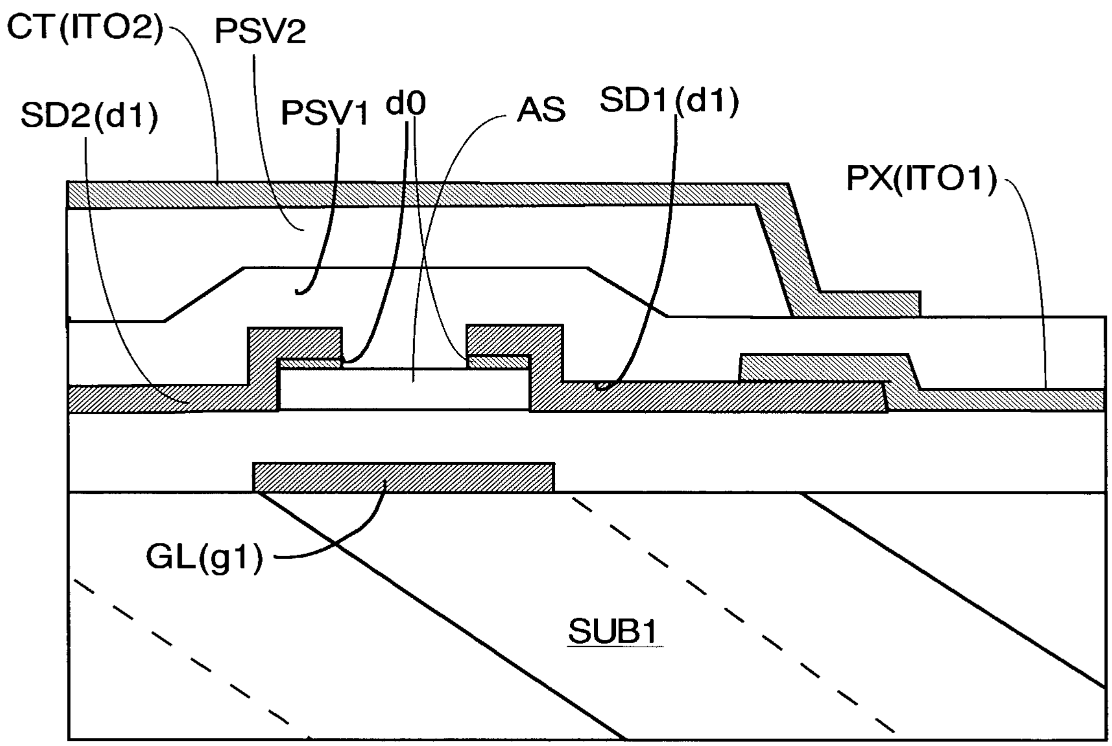


FIG. 34

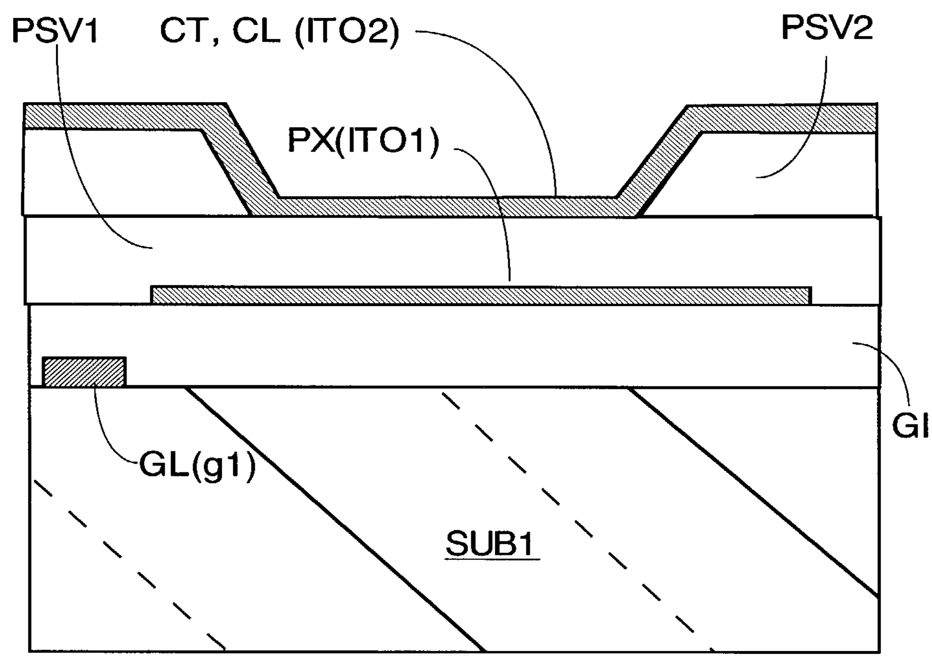
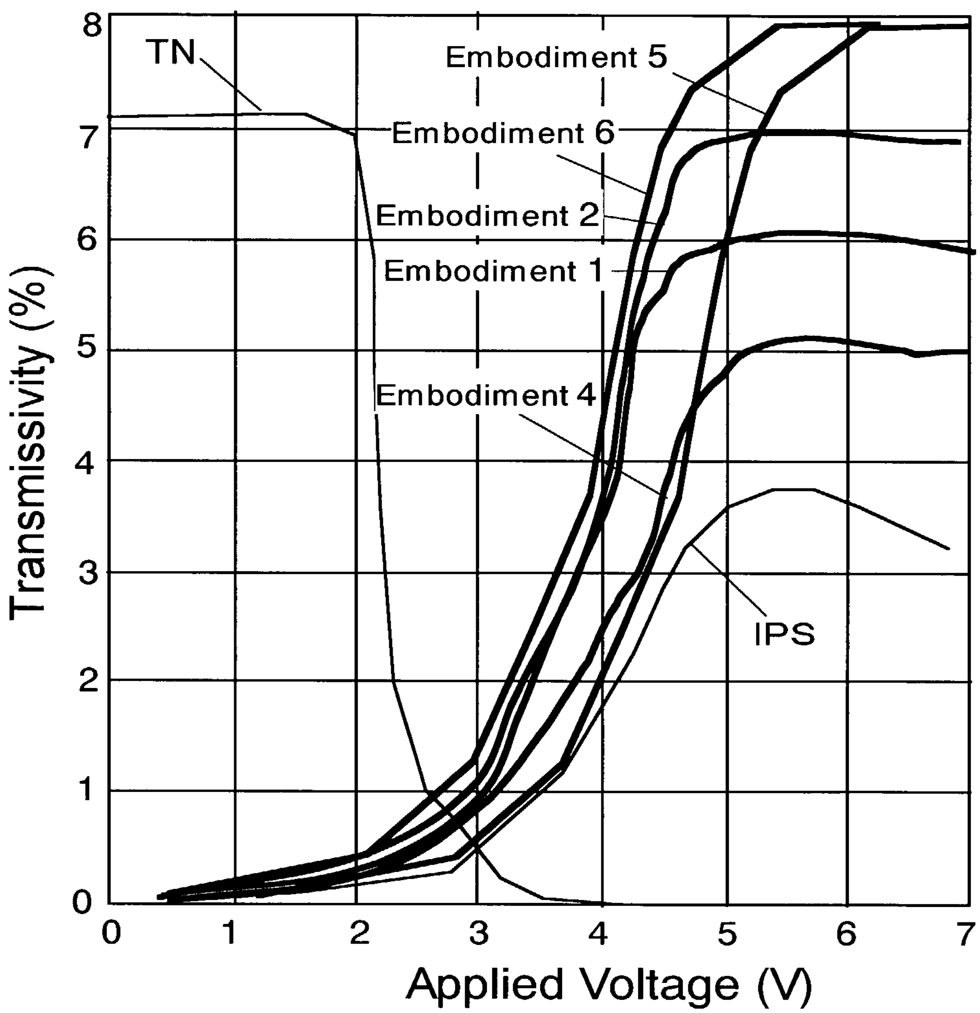


FIG. 35



Transmissivity (%)
Applied Voltage (V)
0
1
2
3
4
5
6
7
8
TN
Embodiment 5
Embodiment 6
Embodiment 2
Embodiment 1
Embodiment 4
IPS

FIG. 36

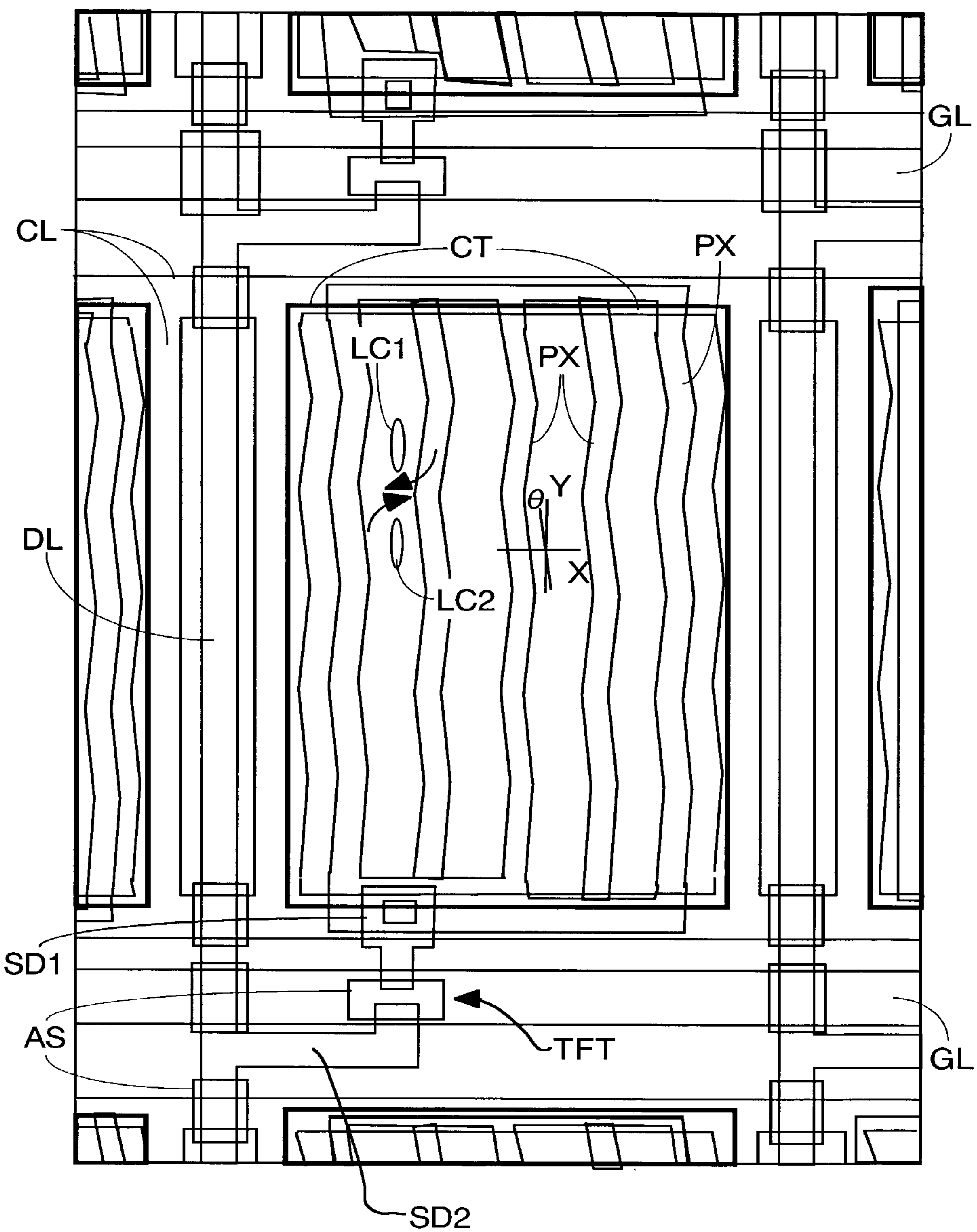


FIG. 37

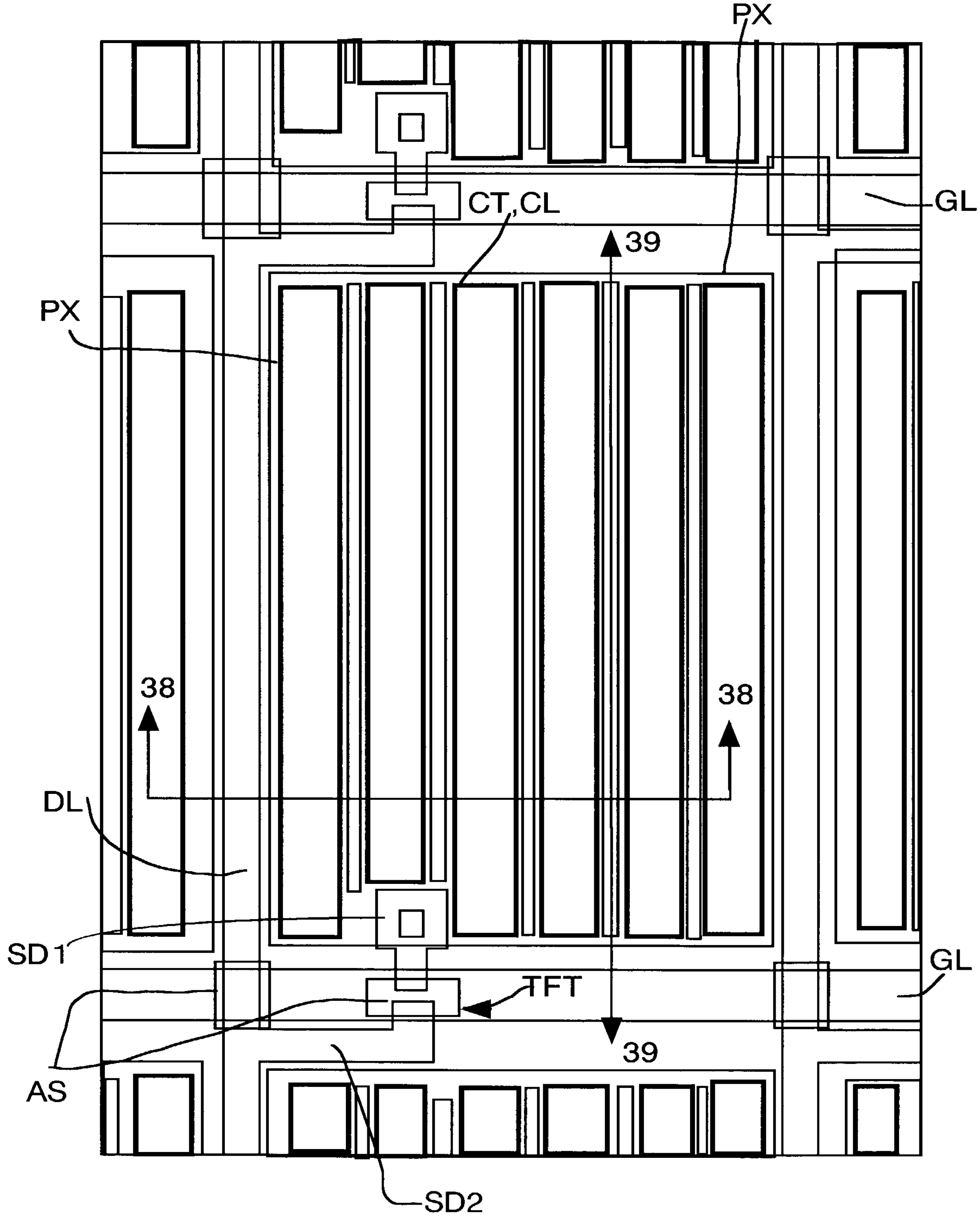


FIG. 38

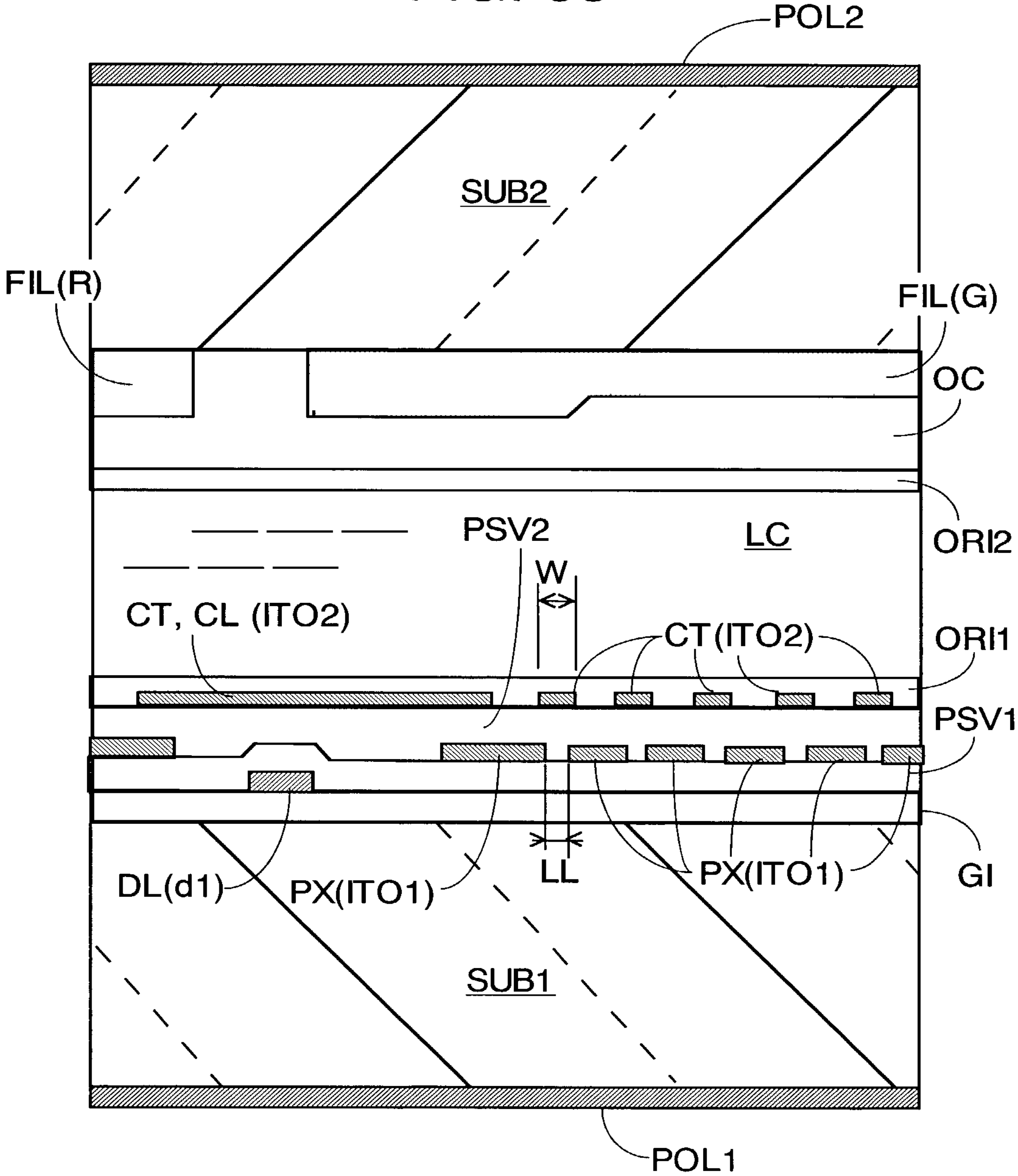

POL2
SUB2
FIL(R)
FIL(G)
OC
ORI2
LC
PSV2
W
CT, CL (ITO2)
CT(ITO2)
ORI1
PSV1
DL(d1)
PX(ITO1)
LL
PX(ITO1)
GI
SUB1
POL1

FIG. 39

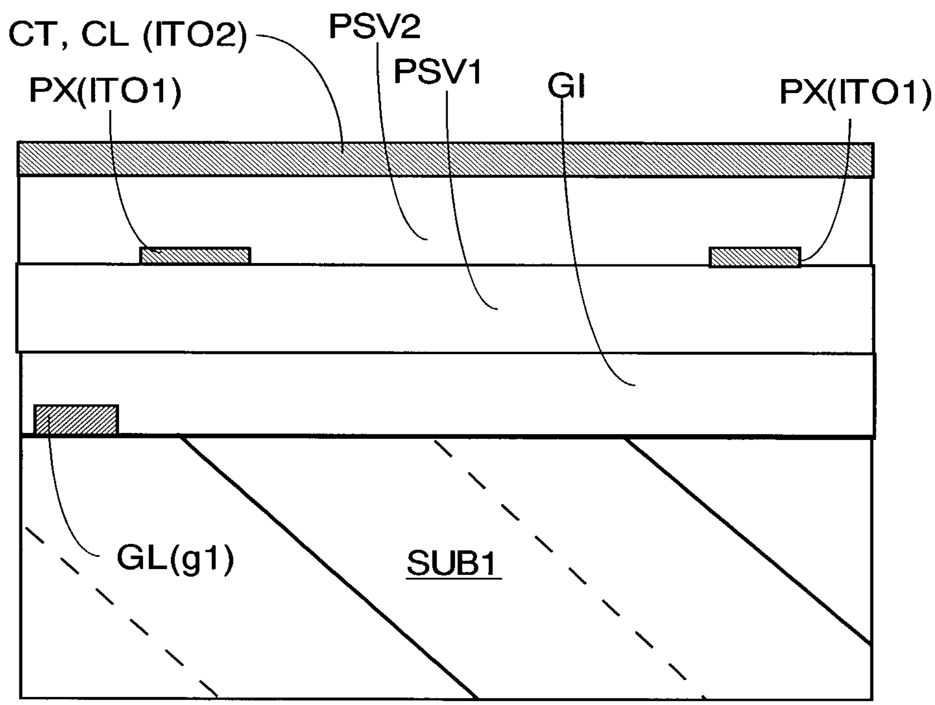


FIG. 40

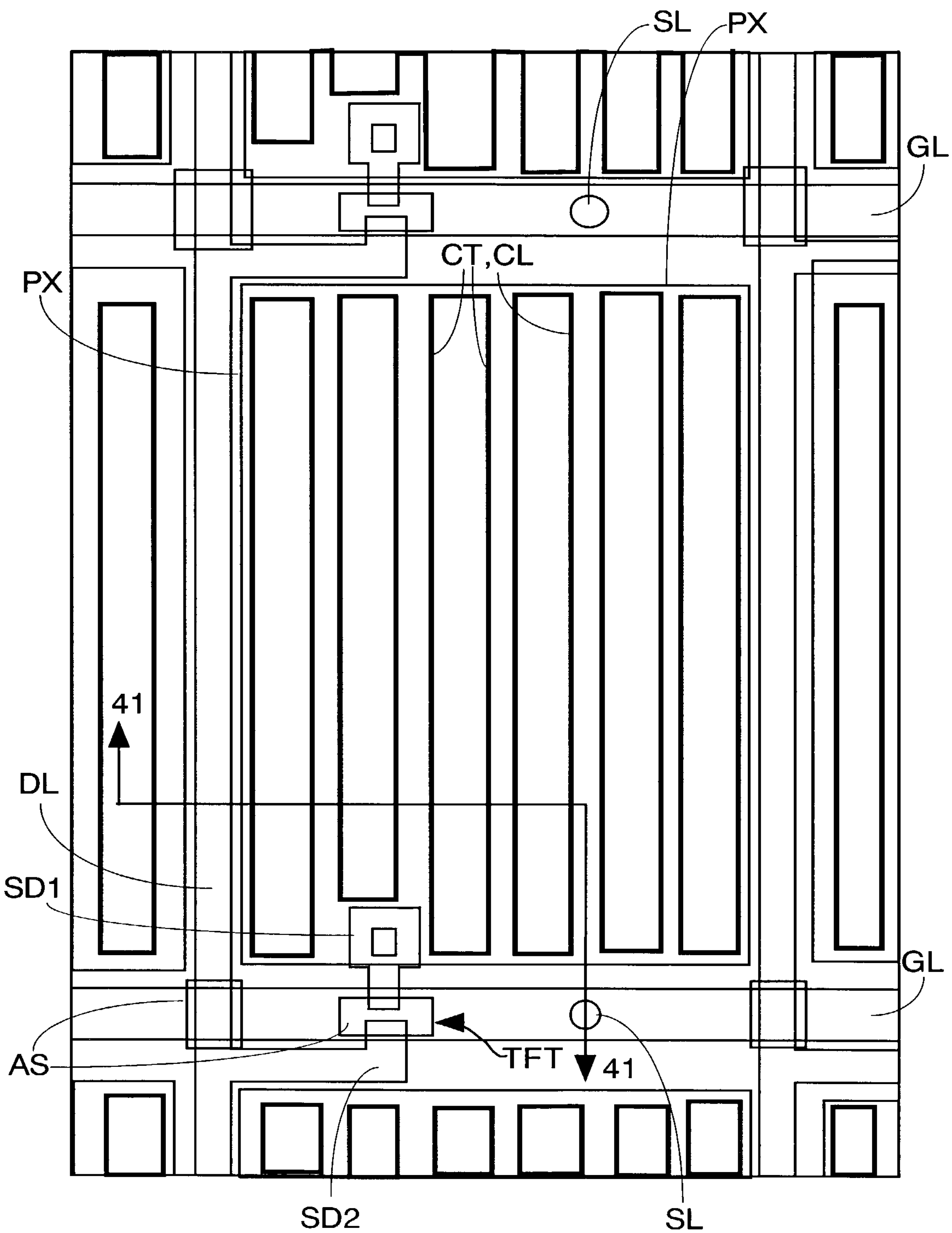


FIG. 41

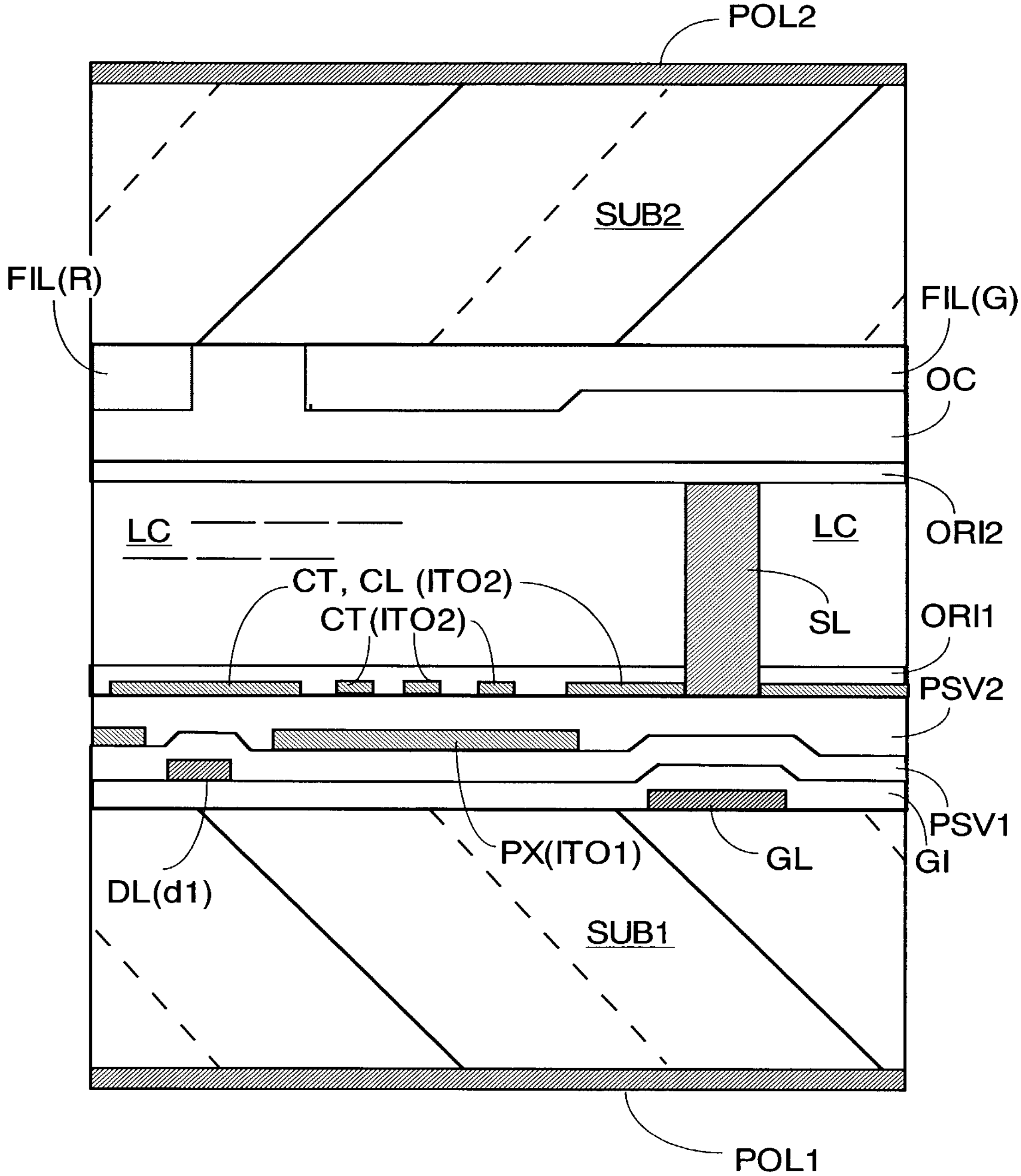

POL2
SUB2
FIL(R)
FIL(G)
OC
LC
LC
ORI2
CT, CL (ITO2)
CT(ITO2)
SL
ORI1
PSV2
PSV1
PX(ITO1)
GL
GI
DL(d1)
SUB1
POL1

FIG. 42A

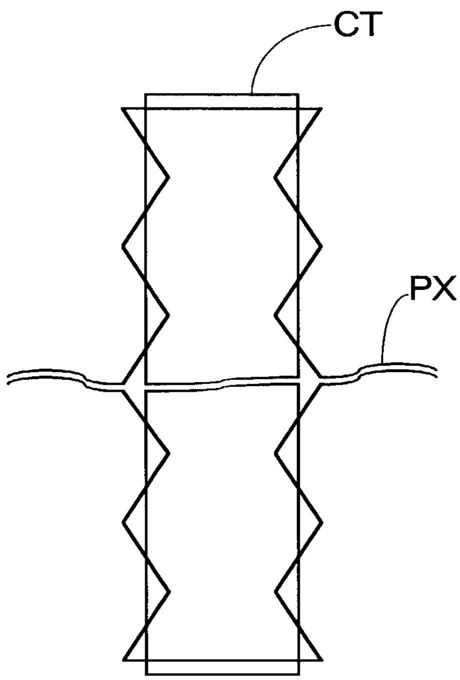


FIG. 42B

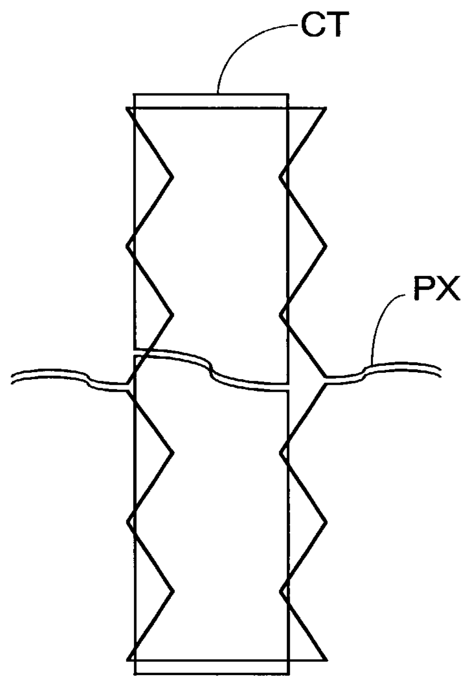
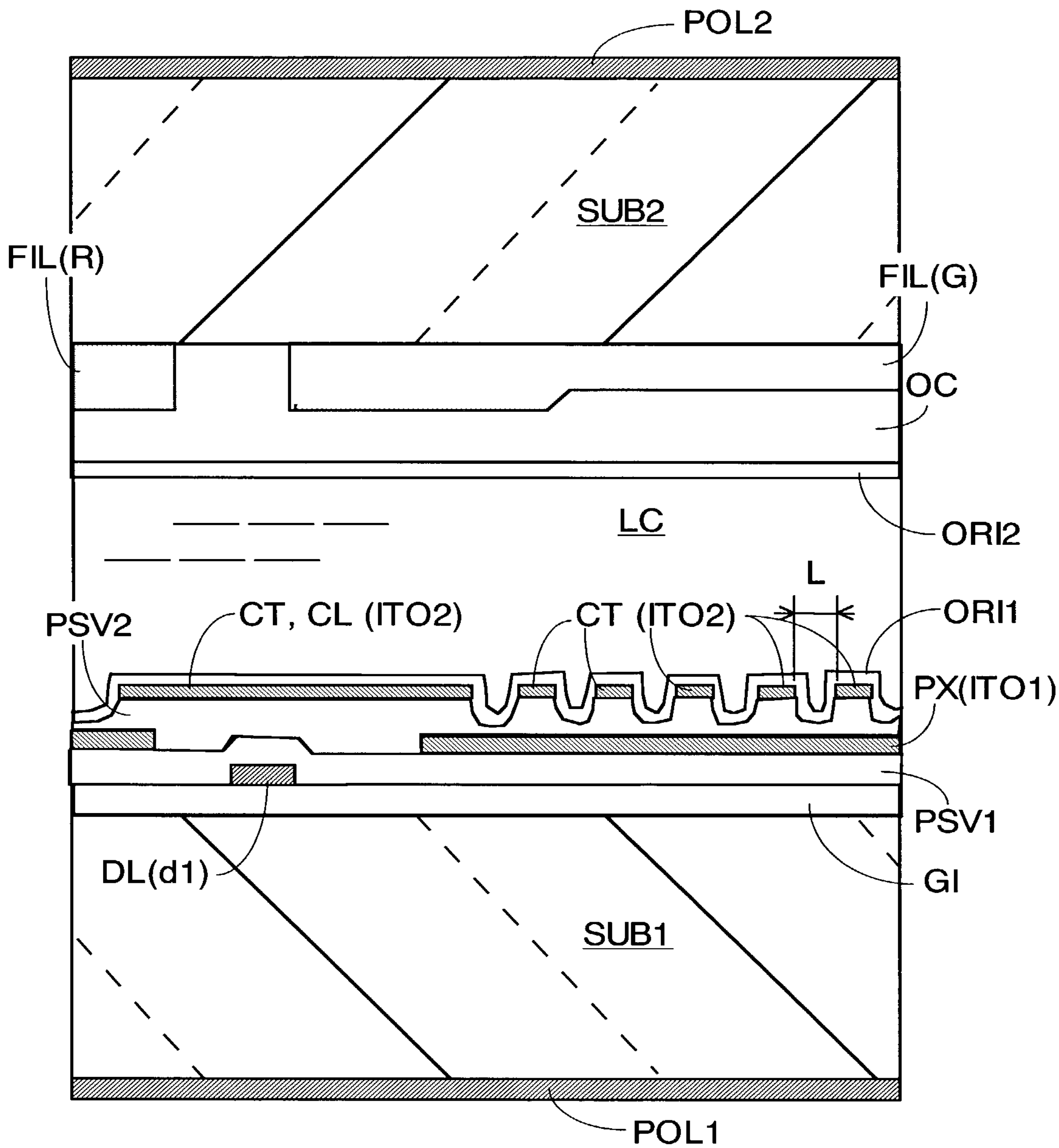


FIG. 43



POL2
SUB2
FIL(R)
FIL(G)
OC
LC
ORI2
L
PSV2
CT, CL (ITO2)
CT (ITO2)
ORI1
PX(ITO1)
PSV1
DL(d1)
GI
SUB1
POL1

FIG. 44

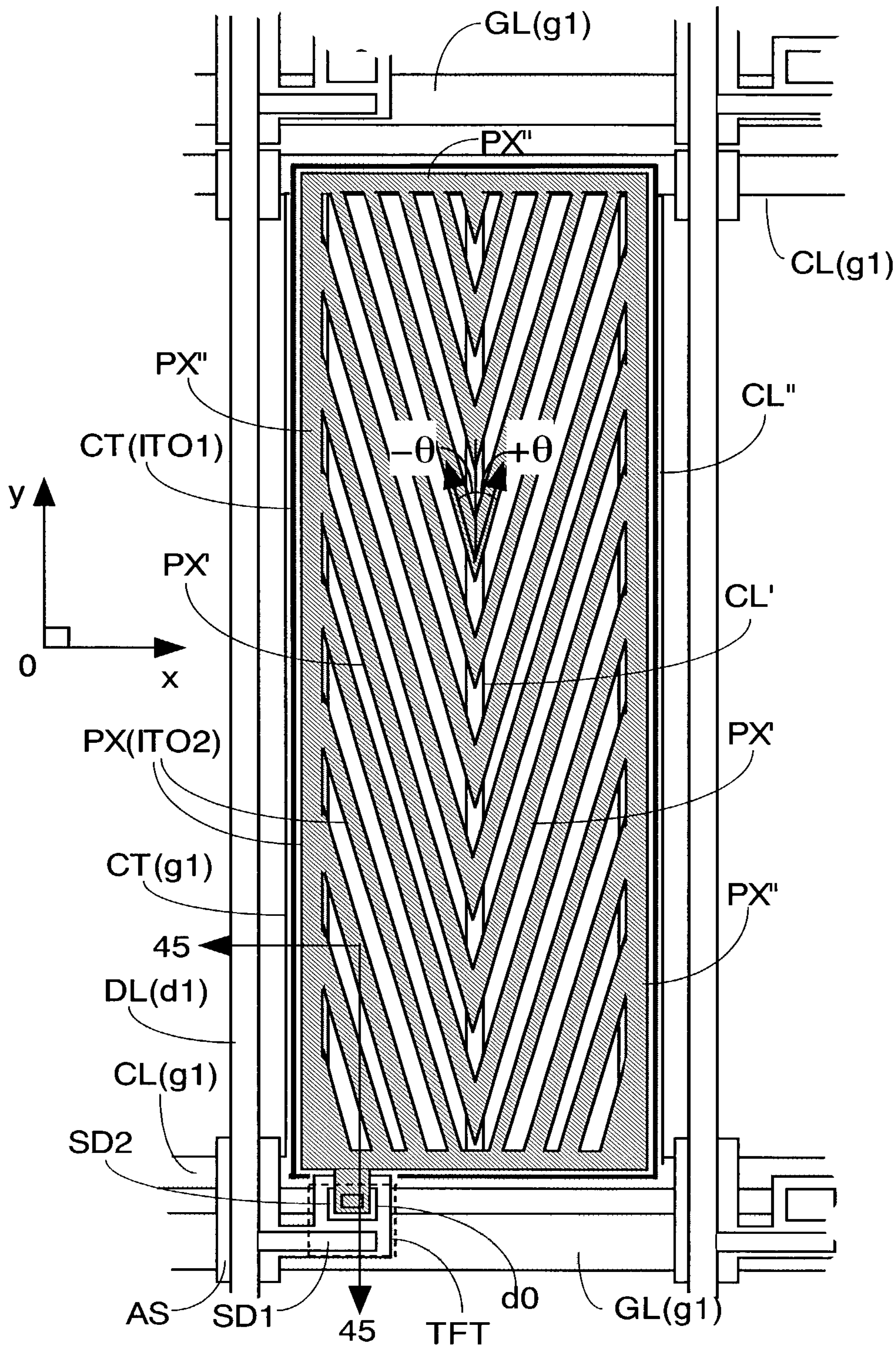

GL(g1)
PX''
CL(g1)
PX''
CL''
CT(ITO1)
$-\theta$
$+\theta$
y
PX'
CL'
0
x
PX(ITO2)
PX'
CT(g1)
PX''
45
DL(d1)
CL(g1)
SD2
AS
SD1
45
TFT
d0
GL(g1)

FIG. 45

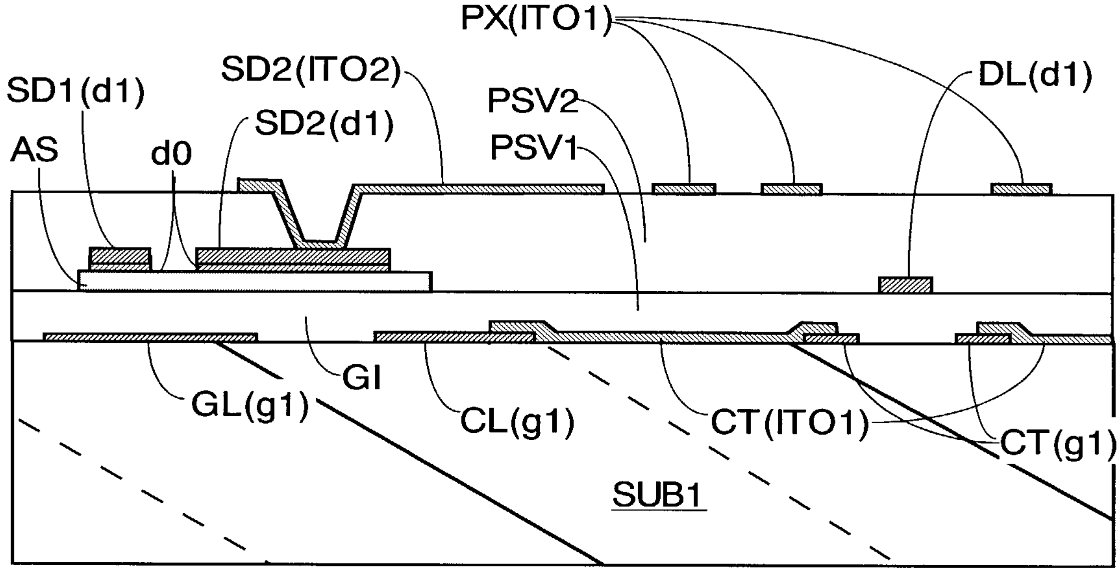

PX(ITO1)
SD2(ITO2)
DL(d1)
SD1(d1)
PSV2
SD2(d1)
AS
d0
PSV1
GI
GL(g1)
CL(g1)
CT(ITO1)
CT(g1)
SUB1

FIG. 46

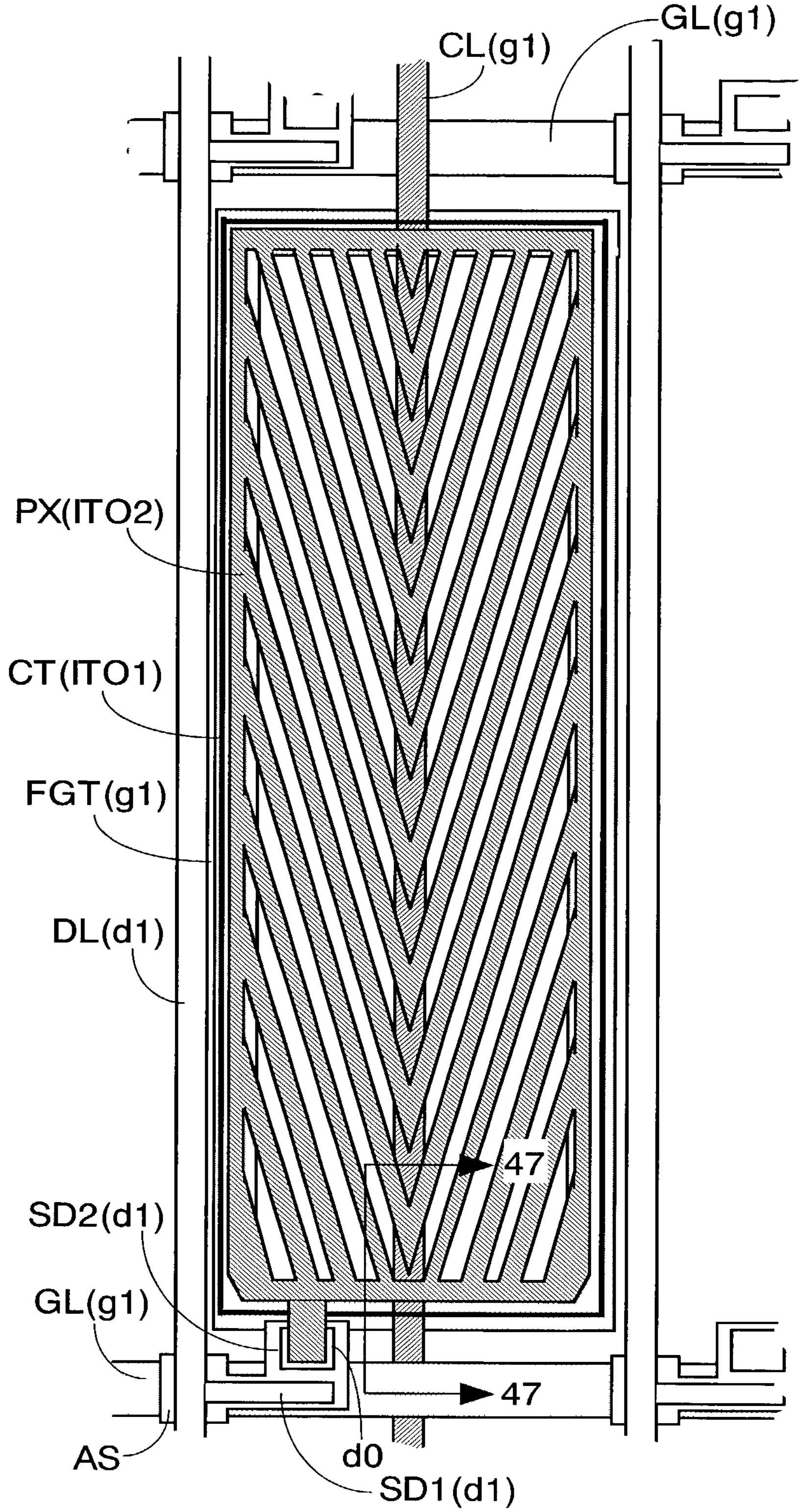

GL(g1)
CL(g1)
PX(ITO2)
CT(ITO1)
FGT(g1)
DL(d1)
47
SD2(d1)
GL(g1)
47
AS
d0
SD1(d1)

FIG. 47

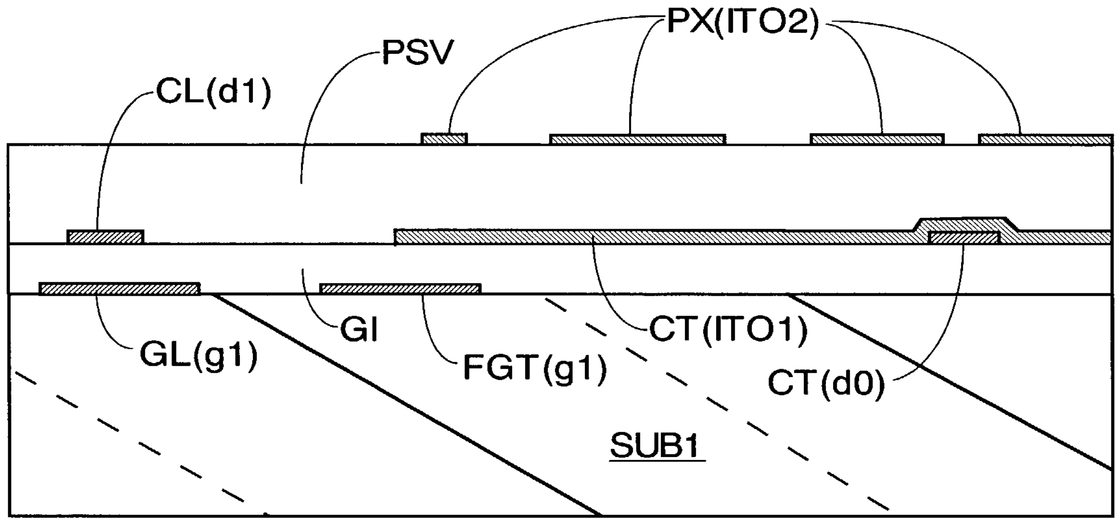


FIG. 48

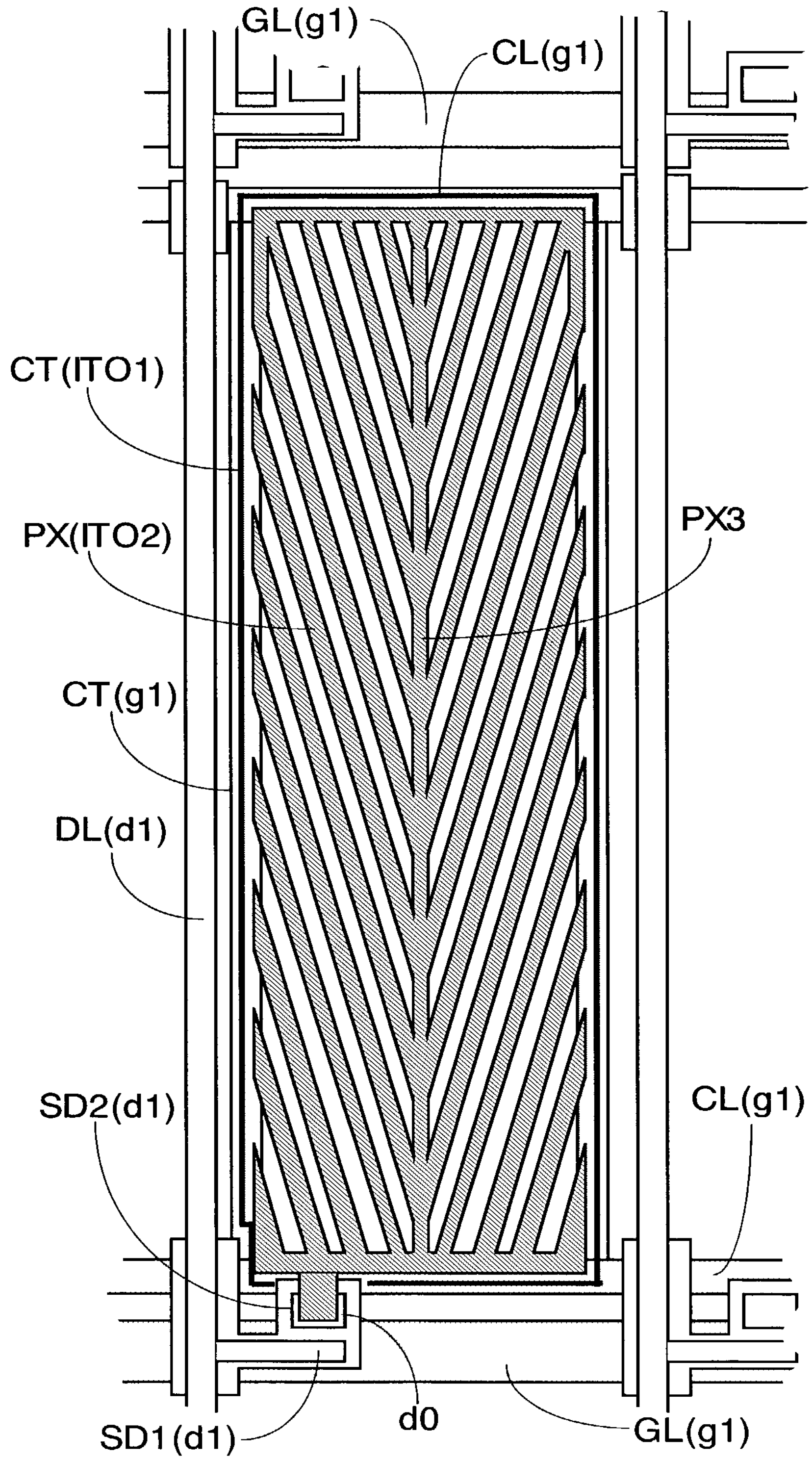

GL(g1)
CL(g1)
CT(ITO1)
PX(ITO2)
PX3
CT(g1)
DL(d1)
SD2(d1)
CL(g1)
SD1(d1)
d0
GL(g1)

FIG. 49

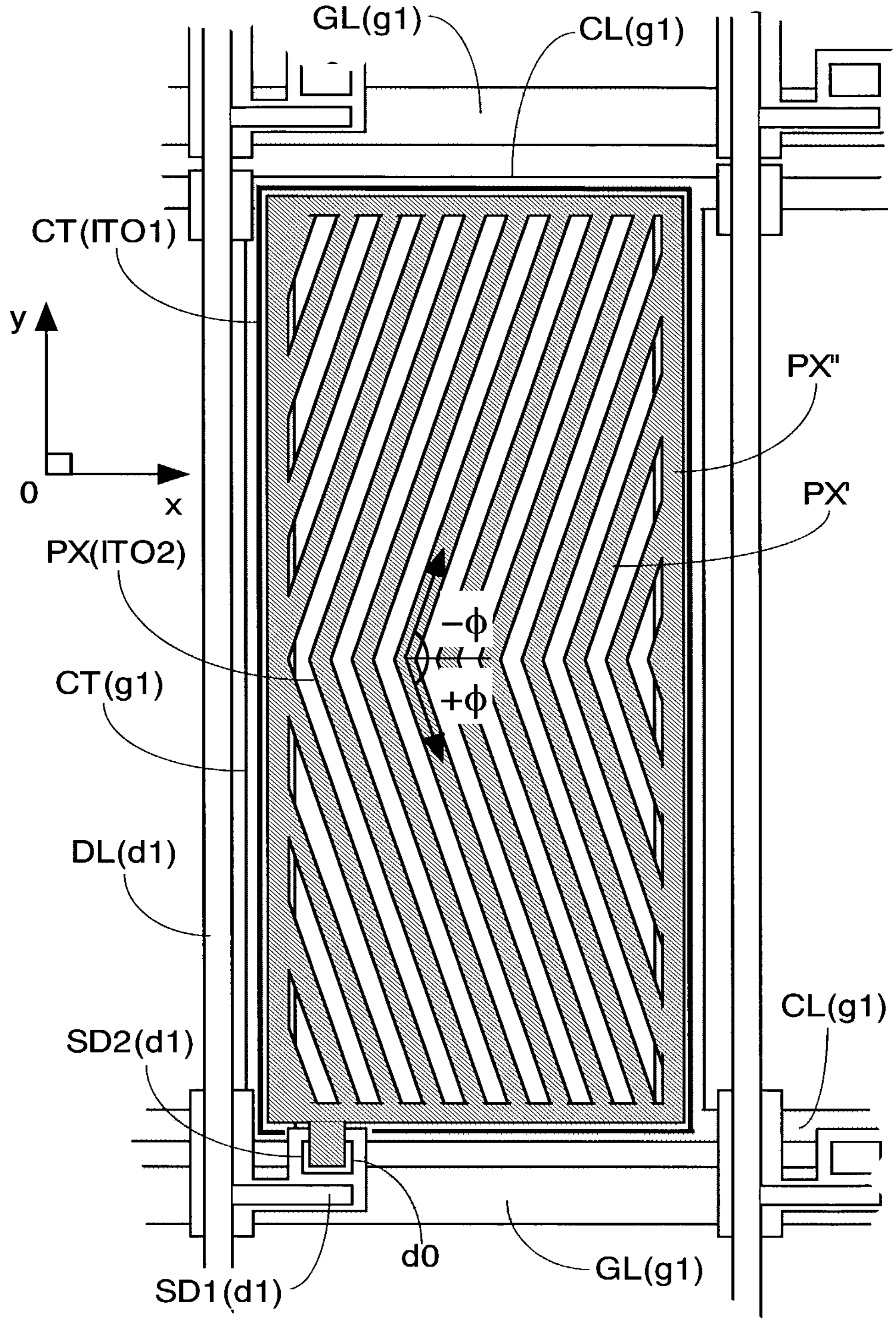
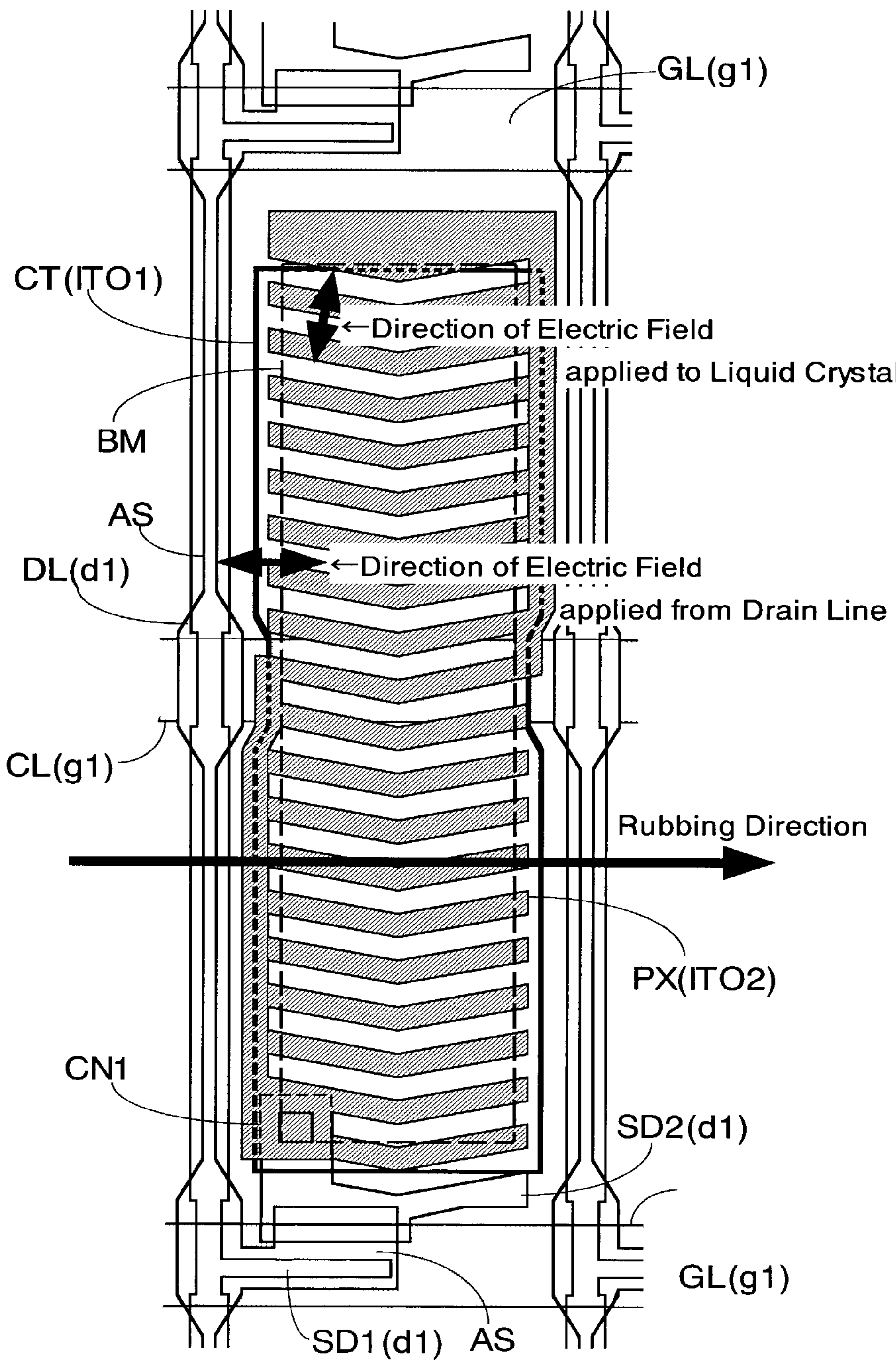

GL(g1)
CL(g1)
CT(ITO1)
y
0
x
PX"
PX'
PX(ITO2)
−ϕ
+ϕ
CT(g1)
DL(d1)
CL(g1)
SD2(d1)
d0
GL(g1)
SD1(d1)

FIG. 50


GL(g1)
CT(ITO1)
←Direction of Electric Field applied to Liquid Crystal
BM
AS
DL(d1)
←Direction of Electric Field applied from Drain Line
CL(g1)
Rubbing Direction
PX(ITO2)
CN1
SD2(d1)
GL(g1)
SD1(d1)
AS

Please type a plus sign (+) inside this box → [+]

PTO/SB/122 (11-96)
Approved for use through ... OMB 0651-0035
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

JC10 Rec'd PCT/PTO 07 MAR 2002

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Application

Address to:
Assistant Commissioner for Patents
Washington, D.C. 20231

Application Number	10/070538
Filing Date	March 7, 2002
First Named Inventor	ONO, et al.
Group Art Unit	
Examiner Name	
Attorney Docket Number	501.41304X00

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I am the :

☐ Applicant.

☐ Assignee of record of the entire interest.
Certificate under 37 CFR 3.73(b) is enclosed.

[X] Attorney or agent of record .

Typed or Printed Name	Melvin Kraus	Registration NO. 22,466
Signature	Donald R Stuart #26422 for Melvin Kraus	
Date	March 7, 2002	

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Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Liquid Crystal Display Device

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ __月__日に提出され、米国出願番号または特許協定条約国際出願番号を__________とし、(該当する場合) __________に訂正されました。

☐ was filed on
as United States Application Number or
PCT International Application Number
__________ and was amended on
__________ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

PTO/SB/106(8-96)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMETNT OF COMMERCE

Japanese Language Declaration
(日本語宣言書)

私は、米国法典第３５編１１９条 (a) - (d) 項又は３６５条(b)項に基き下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約３６５ (a) 項に基ずく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示している。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
PCT / JP00 / 06009	Japan	5 / September / 2000	☐
11-252763	Japan	7 / September / 1999	☐

私は、第３５編米国法典１１９条 (e) 項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Application No.) (出願番号)	(Filing Date) (出願日)

私は、下記の米国法典第３５編１２０条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約３６５条 (c) に基ずく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第３５編１１２条第１項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第３７編１条５６項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

私は、私自身の知識に基ずいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基ずく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第１８編第１００１条に基ずき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration
（日本語宣言書）

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

Donald R. Antonelli, Reg. No. 20,296; David T. Terry, Reg. No. 20,178; Melvin Kraus, Reg. No. 22,466; William I. Solomon, Reg. No. 28,565; Gregory E. Montone, Reg. No. 28,141; Ronald J. Shore, Reg. No. 28,577; Donald E. Stout, Reg. No. 26,422; Alan E. Schiavelli, Reg. No. 32,087; James N. Dresser, Reg. No. 22,973 and Carl I. Brundidge, Reg. No. 29,621

書類送付先

Send Correspondence to:

Antonelli, Terry, Stout & Kraus, LLP
Suite 1800
1300 North Seventeenth Street
Arlington, Virginia 22209

直接電話連絡先： (氏名及び電話番号)

Direct Telephone Calls to: (*name and telephone number*)

Telephone: (703) 312-6600
Fax: (703) 312-6666

唯一または第一発明者	1-60	Full name of sole or first inventor Kikuo Ono
発明者の署名	日付	Inventor's signature Kikuo Ono Date Jan. 15, 2002
住所		Residence Mobara, Japan JPX
国籍		Citizenship Japan
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(第二以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for second and subsequent joint inventors.)

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第三共同発明者の署名	日付	Third inventor's signature Date Tsunenori Yamamoto. Jan 15, 2002
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